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WORK PLAN

FOR WATERSHED PROTECTION, FLOOD PREVENTION,
MUNICIPAL WATER SUPPLY AND RECREATIONAL DEVELOPMENT

QUAPAW CREEK WATERSHED

Lincoln and Potawatomie Counties, Oklahoma



PREPARED UNDER THE AUTHORITY OF THE WATERSHED PROTECTION AND FLOOD PREVENTION ACT
(PUBLIC LAW 566, 83RD CONGRESS; 68 STAT. 666) AS AMENDED

Prepared by: Lincoln County Soil and Water Conservation District

Shawnee Soil and Water Conservation District

Town of Meeker, Oklahoma Town of Sparks, Oklahoma

With Assistance By

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE
AUGUST 1964

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WATERSHED WORK PLAN AGREEMENT

between the

Lincoln County Soil and Water Conservation District
Local Organization

Shawnee Soil and Water Conservation District
Local Organization

Town of Meeker
Local Organization

Town of Sparks
Local Organization

State of Oklahoma
(hereinafter referred to as the Sponsoring Local Organization)

and the

Soil Conservation Service
United States Department of Agriculture
(hereinafter referred to as the Service)

Whereas, application has heretofore been made to the Secretary of Agriculture by the Sponsoring Local Organization for assistance in preparing a plan for works of improvement for the Quapaw
Creek Watershed, State of Oklahoma
under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress; 68 Stat. 666), as amended; and

Whereas, the responsibility for administration of the Watershed Protection and Flood Prevention Act, as amended, has been assigned by the Secretary of Agriculture to the Service; and

Whereas, there has been developed through the cooperative efforts of the Sponsoring Local Organization and the Service a mutually satisfactory plan for works of improvement for the Quapaw Creek
Watershed, State of Oklahoma,
hereinafter referred to as the watershed work plan, which plan is annexed to and made a part of this agreement;



Now, therefore, in view of the foregoing considerations, the Sponsoring Local Organization and the Secretary of Agriculture, through the Service, hereby agree on the watershed work plan, and further agree that the works of improvement as set forth in said plan can be installed in about 8 years.

It is mutually agreed that in installing and operating and maintaining the works of improvement substantially in accordance with the terms, conditions, and stipulations provided for in the watershed work plan:

1. The Sponsoring Local Organization will acquire such land, easements or rights-of-way as will be needed in connection with the works of improvement. (Estimated Cost \$617,095). The percentages of this cost to be borne by the Sponsoring Local Organization and the Service are as follows:

<u>Works of Improvement</u>	<u>Sponsoring Local Organizations (percent)</u>	<u>Service (percent)</u>	<u>Estimated Land, Easements, and Rights-of-Way Cost (dollars)</u>
Multiple Purpose Structure No. 1 (Includes value of donated easements and services).	100	-	11,300
<u>Multiple Purpose Structure No. 15 and Basic Recreational Facilities</u>			
Payment to landowners for 736 acres and cost of relocation or modification of improvement.	56.4	43.6	165,100
Flowage Easements (30 acres)	100	-	1,500
Legal Fees, Surveys, and Other Costs	100	-	4,000
<u>All Other Structural Measures</u>	100	-	435,195

2. The Sponsoring Local Organization will acquire or provide assurance that landowners or water users have acquired such water rights pursuant to State law as may be needed in the installation and operation of the works of improvement.
3. The percentages of construction costs of structural measures to be paid by the Sponsoring Local Organization and by the Service are as follows:

<u>Works of Improvement</u>	<u>Sponsoring Local Organization (percent)</u>	<u>Service (percent)</u>	<u>Estimated Construction Cost (dollars)</u>
Multiple Purpose Structure No. 1	37.59	62.41	71,927
Pumping Station and Water Supply Line	100.0	-	6,000
Multiple Purpose Structure No. 15	20.755	79.245	279,470
Pumping Station and Water Supply Line	100.0	-	62,500
Basic Recreational Facilities	50.0	50.0	30,652
Single Purpose Floodwater Retarding Structures Nos. 2 through 14, 16 through 44, and Channel Improve- ment	-	100.0	2,289,414

4. The percentages of the cost for installation services to be borne by the Sponsoring Local Organization and the Service are as follows:

<u>Works of Improvement</u>	<u>Sponsoring Local Organization (percent)</u>	<u>Service (percent)</u>	<u>Estimated Installation Service Cost (dollars)</u>
Multiple Purpose Structure No. 1	37.59	62.41	18,114
Pumping Station and Water Supply Line	100.0	-	720
Multiple Purpose Structure No. 15	16.29	83.71	66,999
Pumping Station and Water Supply Line	100.0	-	6,250
Basic Recreational Facilities	50.0	50.0	4,598
Single Purpose Floodwater Retarding Structures Nos. 2 through 14, 16 through 44, and Channel Improve- ment	-	100.0	587,914

5. The Sponsoring Local Organization will bear the costs of administering contracts. (Estimated cost \$16,400).
6. The Sponsoring Local Organization will obtain agreements from owners of not less than 50% of the land above each reservoir and floodwater retarding structure that they will carry out conservation farm or ranch plans on their land.
7. The Sponsoring Local Organization will provide assistance to landowners and operators to assure the installation of the land treatment measures shown in the watershed work plan.
8. The Sponsoring Local Organization will encourage landowners and operators to operate and maintain the land treatment measures for the protection and improvement of the watershed.
9. The Sponsoring Local Organization will be responsible for the operation and maintenance of the structural works of improvement by actually performing the work or arranging for such work in accordance with agreements to be entered into prior to issuing invitations to bid for construction work.

10. The costs shown in this agreement represent preliminary estimates. In finally determining the costs to be borne by the parties hereto, the actual cost incurred in the installation of works of improvement will be used.
11. This agreement does not constitute a financial document to serve as a basis for the obligation of Federal funds, and financial and other assistance to be furnished by the Service in carrying out the watershed work plan is contingent on the appropriation of funds for this purpose.

Where there is a Federal contribution to the construction cost of works of improvement, a separate agreement in connection with each construction contract will be entered into between the Service and the Sponsoring Local Organization prior to the issuance of the invitation to bid. Such agreements will set forth in detail the financial and working arrangements and other conditions that are applicable to the specific works of improvement.

12. The watershed work plan may be amended or revised, and this agreement may be modified or terminated, only by mutual agreement of the parties thereto.
13. No member of or delegate to Congress, or resident commissioner, shall be admitted to any share or part of this agreement or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this agreement if made with a corporation for its general benefit.
14. The program conducted will be in compliance with all requirements respecting nondiscrimination as contained in the Civil Rights Act of 1964 and the regulations of the Secretary of Agriculture (7 C. F. R. Sec. 15.1-15.13), which provide that no person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any activity receiving Federal financial assistance.

Lincoln County Soil and Water Conservation District
(Local Organization)

By

Title

Date

Bevil Tord

Chairman

March 10, 1965

The signing of this agreement was authorized by a resolution of the governing body of the Lincoln County Soil and Water Conservation District adopted at a meeting held on March 9, 1965

J. DeWorm
(Secretary, Local Organization)

Date

March 10, 1965

Shawnee Soil and Water Conservation District
(Local Organization)

By Glen D. White

Title Chairman

Date March 10, 1965

The signing of this agreement was authorized by a resolution of the governing body of the Shawnee Soil and Water Conservation District adopted at a meeting held on Mar 10 - 1965.

Don C. Ours
(Secretary, Local Organization)

Date Mar 10 - 1965

Town of Meeker
(Local Organization)

By George E. Buoy

Title Mayor

Date March 10, 1965

The signing of this agreement was authorized by a resolution of the governing body of the Town of Meeker adopted at a meeting held on

March 8, 1965.

Marilyn Layton
(Secretary, Local Organization)

Date: March 10, 1965

Town of Sparks
(Local Organization)

By Clyde A Brown

Title Chairman

Date 3/11/65

The signing of this agreement was authorized by a resolution of the governing body of the Town of Sparks adopted at a meeting held on March 2, 1965.

J W Riddle

(Secretary, Local Organization)

Date 3-11-65

(Local Organization)

By _____

Title _____

Date _____

The signing of this agreement was authorized by a resolution of the governing body of the _____

Local Organization

adopted at a meeting held on _____

(Secretary, Local Organization)

Date _____

WORK PLAN
FOR
WATERSHED PROTECTION, FLOOD PREVENTION,
MUNICIPAL WATER SUPPLY AND RECREATIONAL DEVELOPMENT

QUAPAW CREEK WATERSHED
Lincoln and Pottawatomie Counties
Oklahoma

Prepared Under the Authority of the Watershed
Protection and Flood Prevention Acts, (Public
Law 566, 83rd Congress, 68 Stat. 666), as
amended.

Prepared by:

Lincoln County Soil and Water Conservation District
(Sponsor)

Shawnee Soil and Water Conservation District
(Sponsor)

Town of Meeker, Oklahoma
(Sponsor)

Town of Sparks, Oklahoma
(Sponsor)

With Assistance By:
U. S. Department of Agriculture, Soil Conservation Service
August 1964

WATERSHED WORK PLAN
QUAPAW CREEK WATERSHED

Lincoln and Pottawatomie Counties, Oklahoma
August 1964

SUMMARY OF PLAN

General Summary

The work plan for watershed protection, flood prevention, nonagricultural water management, municipal water supply, and recreational development for the Quapaw Creek Watershed, Oklahoma was prepared by the Lincoln County and Shawnee Soil and Water Conservation Districts and the towns of Meeker and Sparks as the co-sponsoring local organizations with technical assistance by the United States Department of Agriculture. The Quapaw Creek Watershed Association has provided the local leadership in the informational phase and in development of the work plan and will continue to function in carrying out the project.

Quapaw Creek rises 10 miles west of Meeker, Oklahoma and flows in an easterly direction to 1 mile north of Meeker and continues northeasterly into the Deep Fork River near the town of Sparks, Oklahoma. The watershed covers 154 square miles. Approximately 17 percent of the watershed is cropland, 80 percent pasture-rangeland, and 3 percent is in miscellaneous uses such as stream channels, towns, and roads. There are 240 acres under the jurisdiction of the Bureau of Indian Affairs. No works of improvement included in this work plan are on Federal owned land.

The flood plain of Quapaw Creek and its tributaries is subject to frequent and severe flooding. Severe flooding has caused scour damage on 1,265 acres of flood plain. Damage ranges from 10 to 40 percent as measured by reduced productivity. A total of 3,789 acres of the flood plain has been damaged by sediment. Damages range from 10 to 60 percent as measured by reduced productive capacity.

The towns of Meeker and Sparks need additional municipal water. Also, a development is needed to furnish water-based recreation including fishing, boating, skiing, riding, and picnicking.

Land Treatment Measures

At the present time 58,642 acres have basic plans for land treatment. Additional land treatment measures will be established by the landowners and operators of watershed lands during the 8-year project installation period. Emphasis will be placed on accelerating the establishment of those land treatment measures which will have a measurable effect on reduction of floodwater and sediment damages and the cost of providing sediment storage capacity in floodwater retarding structures.

The cost of land treatment measures is estimated to be \$940,319, of which other than Public Law 566 share is \$876,319, including expected reimbursements from ACPS, the cost of other going programs, and the value of the land treatment measures which will be installed by individual landowners and operators on their own land. The Public Law 566 share, which consists entirely of accelerated technical assistance, is \$64,000.

Structural Measures

The structural measures included in the plan consist of 42 single purpose floodwater retarding structures; 1 multiple purpose structure incorporating floodwater detention and municipal water supply storage; 1 multiple purpose structure with floodwater detention, municipal and recreational water supply storage, plus basic recreational facilities; and 8.8 miles of channel improvement with appurtenances. The structures will have an aggregate capacity of 31,721 acre feet for floodwater detention, municipal and recreational water supply, and sediment storage. The structures will provide protection to 7,208 acres of flood plain land. The total cost of the structural measures is \$4,058,053, of which the value of the other than Public Law 566 is \$757,354 and Public Law 566 share is \$3,300,699. The value of the local share of the cost of structural measures includes construction cost, \$168,867; installation services, \$26,922; land, easements, and rights-of-way, \$545,095; and administration of contracts, \$16,400.

The following table shows the cost to be paid by Public Law 566 and the towns of Sparks and Meeker on the multiple purpose structures:

Multiple Purpose Structure Number	:	PL-566 Funds	:	Town Funds	:	Total
1 (Sparks)		\$56,195		\$52,666		\$108,861
15 (Meeker)		\$367,176		\$256,393		\$623,569

The average annual damages without the project are:

Floodwater	\$200,977
Sediment	33,473
Scour	8,454
Indirect	24,290
Total	\$267,194

Project Benefits

There are 7,208 acres of flood plain land in the watershed from which flood reduction benefits were claimed. Approximately 83 agricultural landowners in the flood plain will receive direct benefits from the works of improvement. All residents of the watershed and surrounding territory will receive indirect benefits from the increased income stemming from the project.

The average annual benefits accruing to structural measures are:

Damage Reduction	\$169,668
Incidental Recreation	6,115
Recreation	33,060
Municipal Water Supply	16,245
Secondary	20,258
Redevelopment	<u>12,913</u>
Total	\$258,259

The ratio of average annual benefits accruing to structural measures, \$258,259, to the average annual cost of structural measures, \$148,608, is 1.74:1.

The conservation benefits of land treatment measures were not used for project justification, since experience has shown these soil and water conservation measures produce benefits in excess of their costs.

Provisions for Financing

The Lincoln County and Shawnee Soil and Water Conservation Districts are sub-divisions of the State of Oklahoma. Each soil and water conservation district will obtain easements within its own district and will provide for local installation costs. Local responsibilities will be met by donations of land and other services, and by use of State, County, or local revolving funds.

The towns of Meeker and Sparks will provide the local installation cost of their multiple purpose structures, amounting to \$256,393 and \$52,666 respectively. This will be accomplished by donation of land and other services and Farmers Home Administration loan supplemented by grants.

Operation and Maintenance

Land treatment measures will be maintained by the landowners or operators of the farms on which the measures are installed, under agreements with the Lincoln County and Shawnee Soil and Water Conservation Districts. The 42 single purpose floodwater retarding structures and 8.8 miles of channel improvement will be operated and maintained by the two co-sponsoring soil and water conservation districts. The town of Sparks will operate and maintain multiple purpose structure site 1 and the pumping station and water supply line. The town of Meeker will operate and maintain multiple purpose structure site 15, basic recreational facilities and the pumping station and water supply line. The estimated average value of operation and maintenance of the structural measures is \$15,670.

DESCRIPTION OF THE WATERSHED

Physical Data

Quapaw Creek Watershed, with an area of 98,560 acres (154 square miles), is located in east central Oklahoma. The watershed includes 89,658 acres in Lincoln County and 8,902 acres in Pottawatomie County. Quapaw Creek has a dendritic drainage pattern and rises 10 miles west of Meeker, Oklahoma and flows in an easterly direction to 1 mile north of Meeker and continues northeasterly into the Deep Fork River about 1 mile northeast of Sparks, Oklahoma. Main tributaries draining into Quapaw Creek are Wildhorse Creek, Coon Creek, and Spring Creek on the north with Brush Creek, South Quapaw Creek, Sand Creek, and Little Sand Creek on the south.

Flood plain on Quapaw Creek and its tributaries totals 7,208 acres. This amount excludes 426 acres of stream channels. The flood plain averages in width from 875 feet in the upper reach to 2,050 feet at the lower reach.

The mean sea level elevation ranges from 785 feet to 1,180 feet. The channel slopes range from 1.5 feet to over 18.0 feet per mile. The topography varies from gently rolling to hilly.

The geological formation exposed in the watershed is the Wellington formation of Permian age which consists of shales, sandstone, and a few thin limestones. The two land resource areas which occur and their major soil series are the Cross Timbers composed of Red-Yellow Podzolic Lithosols (Darnell-Stephenville) and the Central Reddish Prairies composed of Southern Brunizems and Regosols (Renfrow-Zaneis-Vernon).

Most of the upland soils are medium textured, slowly permeable to permeable and moderately productive. The flood plain soils are mostly dark, medium textured, permeable and very productive.

The following table lists the land use of the watershed:

<u>Land Use</u>	<u>Acres</u>	<u>Percent</u>
Cultivated Land	16,510	16.8
Range	56,154	57.0
Pasture	22,936	23.2
Miscellaneous use, including roads, Channels, and Urban Areas	<u>2,960</u>	<u>3.0</u>
Total	98,560	100.0

A small percentage of formerly cultivated land has a poor cover of annual grasses and weeds. Very little of the upland area is in cultivation at

the present time. Most of the upland area is in native or tame pasture with a fair to good hydrologic cover. The approximate percentage in each category is:

Good	20 percent
Fair	60 percent
Poor	20 percent

Range sites in the watershed are the Loamy Prairie, Claypan Prairie, Red Clay Prairie, Eroded Red Clay, Loamy Bottomland, Deep Sand Savannah, and Shallow Savannah.

The watershed lies in the moist subhumid climatic zone. The average frost-free period of 217 days extends from March 29 to November 6. Mean temperatures range from 76.1 degrees Fahrenheit in summer to 45.2 degrees in winter. The mean annual temperature is 61.4 degrees Fahrenheit.

The average annual precipitation at the Meeker gage is 34.88 inches. All rainfall data were obtained from records at Meeker and Chandler. Thirty-six percent of the annual rainfall occurs in the months of April, May, and June; 16 percent occurs in July and August; and 18 percent occurs in September and October. Severe storms may occur at any time during the spring and fall and less frequently during the mid-summer and winter months. The annual precipitation has ranged from a minimum of 21.28 inches in 1936 to a maximum of 53.04 inches in 1945.

Economic Data

Lincoln County, in which 90 percent of the Quapaw Creek watershed is located, is a designated Area Redevelopment county. The population of the county decreased from 29,529 in 1940 to 18,783 in 1960. The Oklahoma Employment Security Commission estimated the civilian labor force to average 5,300 persons in 1962, of which 7.2 percent were unemployed.

The Quapaw Creek watershed is in the southern portion of the county and includes the towns of Meeker and Sparks. Meeker, which had a population of 664 in 1960 is located near the center of the watershed. Sparks, located near the confluence of Quapaw Creek and Deep Fork had a population of 186 in 1960.

The eastern boundary of the Greater Oklahoma City complex, which has a population of over 500,000, is presently about 10 miles from the western boundary of the watershed. Shawnee, a city of about 25,000 population is located approximately 5 miles from the watershed's southern boundary. Chandler, the county seat of Lincoln County and a city of about 2,500 population in 1960, is 7 miles from the northern boundary of the watershed. The population and urban sprawl from these population centers are expanding rapidly.

Alfalfa, small grain, and sorghums are the principal crops produced in the watershed. Wheat is the major small grain grown on the flood plain lands. Other crops include tame hays and pecans. The agricultural trend in the watershed is to improve pastures and hay crops.

The major farm enterprises in the area are dairy and beef production. According to the 1959 U. S. Census of Agriculture, the value of all livestock and livestock products sold in Lincoln County in 1959 was \$4,668,674. The value of all farm products sold in the county this same year was \$5,386,017.

Data taken from the U. S. Census of Agriculture showing trends in the agricultural economy of Lincoln County are as follows:

<u>Item</u>	<u>1950</u>	<u>1959</u>
Average size of farm (acres)	187	396
Average per acre value of land and buildings (dollars)	34	53
Owners and part owners operating farms (percent)	69	83
Proportion of tenancy (percent)	31	17
Part-time farmers (percent)	46	62

The watershed is served by approximately 200 miles of county roads and 45 miles of hard surfaced State and Federal highways. The Atchinson-Topeka and the Santa Fe Railroad serves the watershed at Meeker and Sparks.

The production of oil and gas is extensive within the watershed.

Sources of water for municipal, industrial, and recreational uses within the watershed are inadequate. The provision of adequate sources of supply and facilities for these uses are of much importance in the development of the area.

Water for livestock and rural domestic use is supplied from farm ponds, wells, streams, and spring flow. The chief source of water supply for the towns of Meeker and Sparks is wells.

Land Treatment Data

The project area is served by Soil Conservation Service work units at Chandler and Shawnee. These work units provide technical assistance to the Lincoln County and Shawnee Soil and Water Conservation Districts. Assistance to farmers and ranchers in the watershed has been provided in the preparation of 300 basic soil and water conservation plans on 58,642 acres. About 56 percent of the planned practices have been applied (Table 1A).

There are 240 acres of land under the jurisdiction of the Bureau of Indian Affairs. The Land Operations Work Unit Office located at Shawnee furnishes technical assistance to operators of this land.

WATERSHED PROBLEMS

Floodwater Damages

The flood plain (7,208 acres) as considered in this evaluation is that agricultural area below site locations (excluding stream channels and roads) that would be inundated by the runoff from the largest storm in the 20-year evaluation period (1941 through 1960). The storm in this period which produced the largest runoff occurred May 19 - 20, 1955. This rainfall produced a runoff of 4.32 inches, which inundated all of the 7,208 acres of flood plain. The frequency of occurrence of a storm of this size is about once in 25 years on an average.

Major floods covering more than half the flood plain occurred 5 times in 1945 and 1959. There were 4 major floods in 1941, and 3 major floods in each of the years, 1944, 1948, 1950, 1957, and 1960.

During the evaluation period there were 49 major floods which inundated more than 50 percent of the flood plain and 49 minor floods which inundated less than 50 percent of the flood plain. An average of about 4.9 floods occurs annually in the watershed. The accumulated acres flooded by these storms amounts to 17,487 annually.

For purposes of evaluation, the flood plain was divided into 3 reaches (figure 6) as follows:

Reach 1 (3,560 acres) includes the area from the Deep Fork of the Canadian River to Valley Cross Section 15.

Reach 2 (3,184 acres) comprises the main stem flood plain and tributaries of Quapaw Creek, Valley Cross Sections 15 through 28.

Reach 3 (464 acres) is all the main stem flood plain and tributaries on South Quapaw Creek, from Valley Cross Sections S-1 through S-9.

Individual landowners have tried to reduce flooding by building levees and by constructing approximately 6 miles of channel improvement but have had little success. About 2 miles of this channel improvement has aggraded to such an extent that the channel bottom elevation is higher than the flood plain. The outlet of Quapaw Creek and the channel of Deep Fork River have silted to such an extent that flooding occurs in this area on an average of more than once a year.

For the floods considered during the 20-year period studied, the total average annual direct and indirect floodwater damage without project was calculated to be \$225,267, as shown in the following table:

Item	Evaluation Reaches			Total
	1	2	3	
	(dollars)	(dollars)	(dollars)	(dollars)
Crop and Pasture	58,908	42,451	6,912	108,271
Other Agricultural	21,637	17,999	2,807	42,443
Nonagricultural	39,033	8,152	3,078	50,263
(Roads, Bridges, Railroads)				
Indirect	14,012	8,816	1,462	24,290
Total	133,590	77,418	14,259	225,267

The average annual gross value of crop and pasture production per acre (long-term prices) is: Reach 1, \$38.85; Reach 2, \$39.73; and Reach 3, \$39.73. The flood plain areas damaged by sediment and scour are not as productive as adjoining areas. With a project, these areas would be made more productive. Other agricultural damages, including damages to fences and levees, are high for the entire watershed.

Damage is extensive to county roads and bridges in the watershed. Each time there is a major flood, travel is blocked in the flood plain or across it. Interruption of travel, halting of mail, milk trucks, and school bus service, and delay and inconvenience in feeding livestock during flood periods constitute serious problems.

Erosion Damage

Upland sheet erosion from formerly cultivated and cultivated land is the major source of sediment. Gully erosion is moderately severe in some parts of the formerly cultivated land. Roadside erosion is moderate due to steep slopes and no vegetation. Gross erosion from all sources is approximately 1.5 acre feet per square mile per year.

Sheet and gully erosion are the main sources causing downstream damage. Severe flooding has caused scour damage on 1,265 acres of the flood plain. Damage ranges from 10 to 40 percent as measured by reduced productivity. Presently, there are 1,130 acres damaged 10 percent; 117 acres damaged 20 percent; 18 acres damaged 40 percent. Sheet scour is the most severe and has scoured from 4 to 12 inches of surface soil. During the past few years flood plain scouring has decreased due to changes in upland uses such as soil bank, decrease in cultivation, etc. Damages from scour without the project are estimated to be \$8,454 annually.

Bank erosion of minor extent has occurred in areas where the channel has been straightened. The amount of land loss is minor and was not reduced to monetary terms.



Flooding - Storm of 1958



Sediment damage - Storm of 1958

Sediment Damage

Channel filling and overbank deposition have caused increased flooding and the development of low, swampy areas.

Damage by sediment deposition on the flood plain of Quapaw Creek ranges from slight to severe. A total of 3,789 acres, about 53 percent of the total flood plain, has been damaged by deposits of silty sand and fine sand ranging in depth from 6 inches to over 4 feet. Damages are estimated to range from 10 to 60 percent in terms of reduced productivity capacity. At present there are 1,521 acres damaged 10 percent; 486 acres damaged 20 percent; 927 acres damaged 30 percent; 549 acres damaged 40 percent; 120 acres damaged 50 percent; and 186 acres damaged 60 percent. A total of 123 acres of flood plain is damaged 81 percent due to swamping and has caused damages estimated at \$3,499 under present conditions. Damage from overbank deposition under present conditions amounts to \$29,693. Sediment deposition on roads and bridges has been moderate.

Under present conditions it is estimated that 9 acre feet of sediment is being delivered annually to the Eufaula Reservoir site. This represents an annual monetary damage of \$281.

Burning of tree and grass cover has not been a major problem in the watershed. Educational programs showing the detrimental effects of burning have been effective in preventing fires. These programs have been supported by the schools, the towns, the Extension Service, and the local soil conservation districts.

Problems Relating to Water Management

Drainage needs can be met by on-farm drainage systems when channel capacity lost through sediment deposition is restored.

In discussions with local sponsors irrigation storage possibilities were pointed out, but not enough interest was shown to include irrigation as a project purpose.

The towns of Meeker and Sparks do not have ample municipal water supply under present conditions. Well water in the Sparks area is of low quality. This has hampered their growth. Additional municipal water supplies are needed. Dependable sources can best be provided by surface storage reservoirs.

At the present time Quapaw Creek flows intermittently. Impoundment areas along the creek have filled with sediment, leaving very little habitat for fish. Fair cover conditions exist for wild game habitat along the channels and in wooded pasture.

Some farm ponds in the vicinity of Meeker are available for recreational uses. Other outdoor recreational developments within a reasonable distance are Shawnee and Tecumseh lakes. A limited amount of fishing is provided along the Deep Fork and North Canadian Rivers.

The local sponsors have indicated a desire for a water-based recreational development that would furnish fishing, boating, skiing, riding and picnicking.

Under normal rainfall conditions wells, cisterns, and farm ponds furnish sufficient water for domestic use, but during extended droughts some sources of the supply become inadequate.

PROJECTS OF OTHER AGENCIES

Eufaula Reservoir

The Eufaula project is being constructed under the supervision of the U. S. Army District, Tulsa Corps of Engineers. The dam site is located on the Canadian River approximately 12 miles east of Eufaula, Oklahoma. The project completed is for flood control, hydroelectric power, navigation, recreation, and fish and wildlife purposes. The Deep Fork River flows into the reservoir approximately 175 river miles below the mouth of Quapaw Creek.

A survey report for the Deep Fork River basin is being developed by the Corps of Engineers. This is a survey report relative to improvements in the interests of navigation, water supply, and related purposes.

If, as a result of the installation of the navigation project, an adequate outlet is provided for Quapaw Creek, it would then be feasible to increase the level of protection on the Quapaw Creek watershed. The proposed works of improvement, including land treatment, on Quapaw will be beneficial to the proposed navigation project by reducing sediment output and peak flows from the watershed.

The Army Corps of Engineers and Soil Conservation Service have coordinated their studies in the planning stage. Alternate solutions to problems have been considered and rejected in favor of the proposed plan. This coordination will be continued in construction and operation.

BASIS FOR PROJECT FORMULATION

Flood problems on the flood plain land, damages to nonagricultural installations and nonagricultural water management needs were reviewed with the local sponsors and other interested groups. It was determined in preliminary investigation that a high level of control would be needed to provide the desired reduction in flood damages.

It was agreed by the sponsors and the Service to plan a project that would:

1. Include land treatment measures, based on current needs, which can be applied during the project installation period and which will contribute directly to watershed protection and flood prevention.

2. Reduce average annual agricultural and nonagricultural floodwater damages approximately 70 percent. The limited capacity of the Deep Fork River channel was one of the primary considerations in setting the level of protection on Quapaw Creek watershed.
3. Provide the needed protection by floodwater retarding structures insofar as possible.

The proposed navigation project of the Corps of Engineers, if authorized and installed, will improve the outlet conditions at the mouth of Quapaw Creek.

4. Improve the Quapaw Creek channel from a point 4 miles west to a point 4.8 miles east of State Highway 18 to carry the runoff from a 1-year frequency storm under average conditions.
5. Provide a municipal water supply for the towns of Meeker and Sparks, Oklahoma.
6. Provide a recreational development for the community of Meeker.

The size and location of the floodwater retarding structures were influenced by the level of protection needed to meet project goals, by obstructions such as highways, county roads, farmsteads, utility lines, oil field development, etc., the location of flood plain areas needing protection and the desire of the cities of Meeker and Sparks for adequate water supply. The land treatment measures, floodwater retarding structures, channel improvement and multiple purpose structures are the most economical means of solving the watershed problems and meeting the project objectives.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

An effective conservation program is necessary for a sound flood prevention program on the watershed. The basic objectives of the conservation program are the use of each acre of agricultural land within its capabilities and the establishment and maintenance of soil and water conservation practices essential to proper land use. Land treatment practices already installed (Table 1A) show that landowners in the watershed are now using basic conservation programs in their farming operations. Emphasis will be placed on acceleration of the present program being carried on by the Lincoln County and Shawnee Soil and Water Conservation Districts, and the Shawnee Work Unit of the Bureau of Indian Affairs.

Installation of planned land treatment measures will be essential in reducing the volume of sediment and runoff delivered to multiple purpose structures, floodwater retarding structures, and the channel improvement.

Land treatment measures will be installed by landowners and operators during the 8-year project installation period. A longer installation period is required for Quapaw Creek watershed to permit time for installing all needed measures in proper sequence. An estimate of acres to be treated and the cost of treatment are given in Table 1.

Cropland treatment measures to improve soil conditions include conservation cropping systems, cover and green manure crops, crop residue use, and stubble mulching.

Supplementary to these soil improving measures are contour farming, terracing, diversion construction, and grassed waterways. Grassland treatment includes range seeding, pasture planting, proper use of range and pasture, and pond construction to establish or improve soil cover. Application of these measures will have a significant effect in reducing erosion damage, sediment production, and peak discharge of runoff water. Also, the rate of rainfall absorbed by the surface soil will be increased by improved soil and water conditions.

Farm drainage, consisting of field ditches and land grading is needed on areas where surface drainage is poor. The need for drainage results from deposition of sediment in the creek channels. With the structural measures in place, these drainage measures can be installed.

Structural Measures

A system of 42 single purpose floodwater retarding structures, 1 multiple purpose structure incorporating floodwater detention and municipal water supply storage; 1 multiple purpose structure with floodwater detention, municipal and recreational water supply storage plus basic recreational facilities, and 8.8 miles of channel improvement comprise the works of improvement needed to provide protection to the flood plain lands, municipal water for Meeker and Sparks, and recreational facilities for Meeker community and others in the watershed. Of the total estimated installation cost of \$4,058,053, \$2,655,296 is for the 42 single purpose floodwater retarding structures, \$732,430 for the two multiple purpose structures including appurtenant facilities, and \$670,327 is for channel improvement.

The system of structures will detain runoff from approximately 57 percent of the entire watershed from a storm that can be expected to occur on an average of once in 25 years. These structures will have a total floodwater detention capacity of 23,047 acre feet and will detain an average of 4.9 inches of runoff from the watershed area above them.

Sediment pool design will conform to the Oklahoma Water Resources Board Resolution of January 10, 1961 and all applicable State Water Laws. Adequate detention storage and release flow are planned to make possible the use of vegetated earth spillways.

Provision is made in all sites for 100-year sediment storage. The principal spillway risers for the 42 single purpose floodwater retarding structures will be set at the 50-year sediment storage elevation. The sediment pools will inundate 565 acres of bottomland and 467 acres of upland. The water supply pools will inundate 208 acres of bottomland and 56 acres of upland. The detention pools will temporarily inundate an additional 553 acres of bottomland and 1,210 acres of upland.

Plate 1 is a schematic drawing of a typical floodwater retarding structure. Location of structural measures is shown on the project map (figure 8). Design and cost data of individual structures are given in Tables 2, 3, 3A, 3B, and 4.

The purpose of the grade stabilization structure is to obtain a stable grade in the channel.

There will be 8.8 miles of channel improvement installed to provide the level of protection agreed to by the sponsoring local organizations and the Service which cannot be provided by floodwater retardation alone. Suitable vegetation to reduce erosion will be used in all channels. The channel improvement will prevent flooding from a 6-hour storm that can be expected to occur on an average of once per year.

The channel improvement is for the purpose of flood prevention only, since the removal of sediment deposition will restore original drainage outlets. Grade stabilization structures (pipe drops) will be installed in side drains and road ditches for the protection of the main channel. About 1,500 feet of dike is planned in the lower section of the channel improvement area to provide the same channel capacity as the channel above and below this section.

Spoil from excavating and improving the stream channel will be shaped or spread adjacent to the channel. In areas where land is in cultivation or improved pasture the spoil will be spread to a maximum height of 3 feet and a maximum 8 to 1 side slope. Where the area to be occupied by the spoil is in the old slough or is still in timber and has to be cleared, the spoil will be shaped to a maximum height of 5 feet and a maximum 4 to 1 side slope. Spoil will be placed on one or both sides depending upon its quantity. When possible spoil will be placed on one side only in order to reduce the right-of-way width. Spoil will be spread within the right-of-way shown on the land rights map.

The location of the channel on the project map is approximate, but it will be designed and constructed within the right-of-way as shown on the land rights map.

No fences will be built within the design depth of flow of any ditch. Where fences cross channels, suitable water gates will be installed for which costs must be borne by local interests. As nearly as possible and practicable, bridges placed across the channel will be designed with adequate capacity and general shape to effect the minimum impedance to design flows within the channel.

Site 1 is planned as a multiple purpose structure with municipal water storage for the town of Sparks. The floodwater detention storage is 200 acre feet. There are 150 acre feet for municipal water supply and 49 acre feet for sediment storage. Cost data, design features, and a plan of the development are shown in Tables 2 and 3 and Figures 2 and 3. A water supply line is planned to carry the water to Sparks.

Site 15 is planned as a multiple purpose structure with municipal water storage and public recreational development for the town of Meeker. Of the total capacity of 6,139 acre feet there are 1,000 acre feet for municipal water supply, 548 acre feet for recreation, 3,739 acre feet for detention, and 852 acre feet for sediment storage. A water supply line is planned to carry the municipal water to Meeker.

The total area needed for site 15 is 766 acres distributed as follows: 30 acres flowage easement, 511 acres within the reservoir taking line (100 feet horizontal from the emergency spillway crest contour), 20 acres additional land, 176 acres for recreational use outside the reservoir taking line, and 29 acres needed for dam and spillway. There are 74 acres of municipal pool (surface area of municipal pool less surface area of recreational pool) included in the 511 acres of reservoir taking line. A schedule of planned facilities is shown in Table 2B. Facilities to be installed for recreational use include access roads, parking areas, sanitary facilities, a boat dock and launching ramp, and picnicking areas. The recreational developments will be available for public use. Cost and design data and a plan for the development are shown in Tables 2 and 3 and Figures 4 and 5.

EXPLANATION OF INSTALLATION COSTS

Land Treatment

Public Law 566 funds are expected to provide technical assistance in the amount of \$64,000 during the 8-year installation period to accelerate the installation of land treatment measures included in the plan for watershed protection. These funds will be in addition to \$37,736 provided under the going program. Landowners and operators will install these measures at an estimated cost of \$838,583 which includes ACPS payments based on present program criteria (Table 1).

Floodwater Retarding Structures

The construction cost of the 42 single purpose floodwater retarding structures (\$1,839,465) and associated installation services cost (\$513,496) will be borne by Public Law 566 funds. The total Public Law 566 cost for the installation of these structures is \$2,352,961. Construction costs include the engineer's estimate and contingencies. The engineer's estimate was based on the unit cost of structures in similar areas modified by special conditions inherent to each individual site. Special features considered were embankment drainage, timber clearing, minor rock excavation, and release flow channels. Ten percent of the engineer's estimate was added as a contingency to provide funds for unpredictable construction costs. These costs were based on data obtained by surface observations and shallow borings on all the sites.

Land, easements, and rights-of-way for these structures will be furnished by the local organizations. Local costs are estimated at \$302,335. These consist of the value of land easements, relocation of utilities and roads, \$284,665; legal fees, \$5,070; and contract administration \$12,600.

Channel Improvement

Estimated construction cost of \$414,604 for the stream channel improvement and associated installation services costs of \$64,549 will be borne by Public Law 566 funds. Estimated construction costs of \$2,345 for the dike and associated installation services cost of \$655 will be borne by Public Law 566 funds. The cost estimate was based on a unit cost for excavation, allowance for necessary pipe drops, and clearing cost. Estimated costs of \$33,000 for the grade stabilization structure and associated installation services costs of \$9,214 will be borne by Public Law 566 funds. Cost of the reinforced concrete grade stabilization structure was estimated separately based on the installed cost for a similar structure on a nearby watershed project. Fifteen percent of the engineer's estimate was added as a contingency fund. These costs were based on data obtained from surface observations and borings along the channel alignment.

Land easements and rights-of-way for the stream channel improvement will be borne by local organizations. The estimated local costs are \$143,960 for the value of the land easements and rights-of-way, \$1,500 for legal fees, and \$500 for contract administration.

Multiple Purpose Structures

The use of facilities method was used to allocate joint costs of multiple purpose structure sites 1 and 15. Cost estimates for construction of the structures were made by the Soil Conservation Service, based on an analysis of costs for the dam and appurtenant items. An allowance of 15 percent was added for contingencies.

Site 1

Allocation of joint cost for Site 1 was made as follows:

Purpose	: :	Acre Feet	: :	Percent
Flood Prevention		249		62.41
Municipal		150		37.59
Total		399		100.0

The following table shows the estimated cost and percent to be paid by Public Law 566 funds and by the town of Sparks.

Multiple Purpose	: :	Public Law 566 Funds	: :	Town Funds
Structure 1	: :	(percent)	: :	(dollars)
Construction	62.41	44,890	37.59	27,037
Installation Services	62.41	11,305	37.59	6,809
Land Easements, Rights- of-Way and Legal Fees	0	0	100	11,300
Water Supply Line	0	0	100	6,720
Contract Administration	0	0	100	800
Total		56,195		52,666

Site 15

Allocation of joint cost for Site 15 was made as follows:

Purpose	: :	Acre Feet	: :	Percent
Flood Prevention		4,591		74.78
Recreation		548		8.93
Municipal		1,000		16.29
Total		6,139		100.00

The following table shows the estimated cost and percent to be paid by Public Law 566 and by the town of Meeker:

Multiple Purpose Structure No. 15	:Public Law 566 Funds: :(percent) :	Town Funds :(dollars):	:	:	:
Construction	79.245	221,466	20.755	58,004	279,470
Installation Services	83.71	56,085	16.290	10,914	66,999
Land, Easements & R/W (To be cost shared - 642 acres)	50.00	64,200	50.00	64,200	128,400
Additional Land to be purchased (94 acres)	0	0	100.00	18,800	18,800
Subtotal	43.60	64,200	56.40	83,000	147,200
Relocation Utilities <u>1/</u>	43.60	7,800	56.40	10,100	17,900
Flowage easement (30 ac.)	0	0	100.00	1,500	1,500
Recreational Facilities					
Construction	50.00	15,326	50.00	15,326	30,652
Installation Services	50.00	2,299	50.00	2,299	4,598
Administration of Cont- racts & Legal Fees <u>2/</u>	0	0	100.00	4,000	4,000
Water Supply Line	0	0	100.00	71,250	71,250
PROJECT TOTAL		367,176		256,393	623,569

1/ Cost sharing based on same percentage as easements and rights-of-way.

2/ Water supply line not included.

Estimated costs for all structural measures and the amounts to be borne by Public Law 566 and other funds are summarized as follows:

Measures	:Public Law 566: : Funds (dollars)	: Other : Costs (dollars)	: Total : Cost (dollars)
42 Floodwater Retarding Structures	2,352,961	302,335	2,655,296
8.8 Miles Channel Improvement	524,367	145,960	670,327
2 Multiple Purpose Structures	423,371	309,059	732,430
Total	3,300,699	757,354	4,058,053

Schedule of Obligations

The following table is an estimated schedule of funds for the 8-year project installation period and covers land treatment and structural measures. This schedule may be adjusted from year to year on the basis of any significant change in the plan desired by the cooperating parties and in light of appropriations and accomplishments actually made.

Fiscal Year	:	Public Law 566	:	Other	:	Total
	:	Funds	:	Funds	:	
	:	(dollars)	:	(dollars)	:	(dollars)
1		280,056		143,534		423,590
2		431,371		418,599		849,970
3		363,455		165,440		528,895
4		399,237		140,950		540,187
5		498,369		194,490		692,859
6		435,315		156,705		592,020
7		424,529		158,455		582,984
8		532,367		255,500		787,867
Total		3,364,699		1,633,673		4,998,372

EFFECTS OF WORKS OF IMPROVEMENT

The combined program of land treatment and structural measures for flood prevention would prevent damages from 45 of the 98 floods such as occurred on this creek during the evaluation period 1941 through 1960. Thirty-eight of the 49 major floods would be reduced to minor floods. Installation of the project will reduce the average annual flood plain inundation from 17,487 acres to 7,249 acres. Average annual flooding to depths greater than 3 feet would be reduced from 5,164 to 1,049.

Agricultural acres inundated below floodwater retarding structures:

Evaluation	Average Recurrence Interval					
	1 Year	2 Years	10 Years			
Reach	Without	With	Without	With	Without	With
(Figure 6)	Project	Project	Project	Project	Project	Project
1	1,960	660	2,510	1,324	3,100	2,240
2	1,180	104	1,480	410	2,125	1,056
3	280	147	323	178	383	234
Total	3,420	911	4,219	1,412	5,608	3,530

The estimated surface runoff from a 24-hour 25-year frequency storm would be 4.32 inches. Such a storm occurred on May 19 - 20, 1955. This volume of runoff, under present conditions, will produce a peak of 28,500 cubic feet per second at the reference valley section 8 (figure 1), and cause flooding of 7,208 acres of flood plain below proposed floodwater retarding sites. The accelerated land treatment program will reduce the surface runoff from this storm to 4.20 inches with an attending peak discharge of 27,700 c.f.s. at valley section 8 and acres flooded to 7,178 acres. The installation and full functioning of the project will further reduce the peak discharge to 7,800 c.f.s. and the area inundated to 4,409 acres. Based on a recurrence of the storms in the evaluation series, the flood threat will be eliminated from approximately 2,801 acres.

Through the application of planned land treatment measures it is estimated that gross soil loss on the upland will be reduced from about 207 acre feet to 185 acre feet per year; a decrease of approximately 10 percent.

The reduced frequency and depth of flooding will significantly reduce floodwater damages to crops and pastures, fences, levees, roads, railroads, bridges, and oil field installations, and make it possible for more efficient and timely travel and communication within the watershed.

Annual flood plain scour with the project will be reduced by approximately 5.5 percent through planned land treatment measures and 71.4 percent with the installation of planned structures. About 2,277 acres, or 60 percent, of the 3,789 acres presently damaged by overbank deposition will be protected from further damage. Sediment yield to the mouth of the watershed will be reduced by land treatment from the present rate of approximately 96 acre feet to 90 acre feet per year, with structural measures the sediment yield will be 42 acre feet per year. The reduction in scour and sediment damages will make it possible for partial to complete recovery of the flood plain lands damaged by these sources.

Reduced sediment yields from the watershed will reduce the amount of sediment delivered to Eufaula Reservoir.

Approximately 83 owners of flood plain lands will be directly benefited by the installation of the structural measures. Businesses that process agricultural products, suppliers for agricultural production, and residents of the watershed and surrounding territory will be indirectly benefited by the project.

Reservoir operation studies were made for the two multiple purpose structures. The water years of 1951 through 1957 were selected for the study. These studies show that sustained yield is available during the critical period for both multiple purpose structures (sites 1 and 15).

The alternative sources of adequate water supply for Meeker and Sparks are wells or surface storage structures. The consulting engineers, hired by these towns, determined that the municipal water storage in the multiple purpose site would be the most economical source of sufficient water of suitable quality for municipal and recreational use.

Opportunities for development of recreational features in the watershed are excellent. The multiple purpose structure site 15 (recreation, municipal, and flood prevention) will be within an hour's drive of any resident of the watershed. Facilities planned will permit full use of the developments such as fishing, skiing, picnicking, and boating. Many of the recreational facilities could be used the entire year, but the most concentrated use will be during the spring and summer months. The peak daily use of the developments is expected to be 750 visitors. In making this estimate, the areas available for recreational use, the kinds and amounts of recreational

facilities available, and similar items were taken into consideration. Estimated average annual use of the development will be 23,200 visitor-days. It is estimated that about 7,000 people will make recreational use of this site annually. In determining average annual visitor-days, consideration was given to depletion of the recreation pool during critical drought periods.

There will be incidental recreational opportunities accruing from use of the sediment pools of the single purpose floodwater retarding structures and from site 1, a multiple purpose lake including storage for both municipal water supply and floodwater retardation.

From a study of similar existing structures in other watersheds and discussions with individual owners, it was determined that most of the structures would be open to the public. With some limitations of fishing, swimming, boating, picnicking, camping, and hunting will be permitted. For many types of water-based recreation the sediment pools could be used the entire year, but the most concentrated use will be during the spring and summer months. It is estimated that 7,500 people will derive recreational use from the sediment pools annually. The peak daily use is expected to be 700 people. In estimating average annual visitor days, consideration was given to depletion of sediment pools during critical drought periods.

Game habitat will be improved by the following:

1. The wildlife use of the flood plain will be generally improved by reduction of frequency, depth, and duration of flooding.
2. The sediment pools will provide habitat for fish. Waterfowl will also benefit by having feeding and resting areas during the migration seasons. Species such as beaver, muskrat, and racoon will derive some benefit from the permanent water.
3. The stream flow below structures is expected to be more constant and prolonged; this will benefit numerous species of wildlife.
4. Excellent cover will be established on the dams and the emergency spillways of the floodwater retarding structures.
5. Improvement of wildlife and upland game habitat in the recreational area (Table 1) of site 15 by:
 - a. Vegetating and landscaping.
 - b. Protecting wildlife habitat by fencing 736 acres.
6. Application of conservation practices on 55,963 acres of grass land.

The project will create additional employment opportunities for the local residents. The firms contracting for installation of the structures will hire skilled and unskilled labor from the immediate locality. The operation and maintenance of project measures over the life of the project will also provide employment opportunities for the local residents.

Secondary benefits stemming from the project are realized from transporting, processing, and marketing agricultural commodities produced as a result of reducing crop losses by flooding. Secondary benefits induced by the project include the increased net returns to suppliers of farm equipment and materials to achieve the increased agricultural production made possible by the project, the increased net return to local retailers and wholesalers from consumer expenditures by the farm family resulting from increased farm income, and other increases in net returns resulting from costs directly associated with marketing or using project goods or services.

PROJECT BENEFITS

The estimated average annual monetary floodwater, sediment, scour, and indirect damages (table 5) within the watershed will be reduced from \$267,194 to \$81,643 by the proposed project. This is a reduction of 69.44 percent. The average annual benefits as a result of this reduction are as follows:

Crop and Pasture	\$62,536
Other Agricultural	33,139
Nonagricultural	41,245
Sediment (overbank deposition)	24,331
Swamping	1,753
Eufaula	156
Erosion (flood plain scour)	5,523
Indirect	<u>16,868</u>
Total	\$185,551

The effect of land treatment measures in reducing flooding will result in the accrual of \$15,833 in average annual benefits, or about 8.5 percent of the total benefits of \$185,551.

The average annual municipal water supply benefits accruing from multiple purpose sites 1 and 15 are estimated to be \$16,245. Municipal water supply benefits were determined from cost data supplied by the consulting engineers for the towns of Sparks and Meeker.

Incidental recreational benefits will accrue as a result of the municipal storage in site 1 and the sediment pool areas of the single purpose floodwater retarding structures. With minor limitations, approximately 80 percent of the single purpose structures will be open to the public. It is estimated that the available permanent pool surface area of 520 acres will attract 18,200 visitor days annually. A value of \$0.50 per visitor-day

was used in the determination of the incidental recreation benefits. This value was discounted to allow for associated costs and inconstant accrual of benefits. The total average annual incidental recreational benefits are estimated to be \$6,115.

Recreational water stored in multiple purpose site 15, with 176 surface acres of water and 176 adjacent acres on which service facilities will be constructed, will provide excellent opportunities for recreation for the residents of Meeker and the surrounding area. Total estimated recreational benefits are \$33,060. The average annual use will be 23,200 visitor-days, valued at \$1.50 per visitor-day, discounted for a lag in the accrual of benefits.

Redevelopment benefits were used for project justification since the watershed is located in an area designated by the Secretary of Agriculture under the Area Redevelopment Act. Project installation will provide opportunities for employment of local labor presently unemployed or under-employed. Data from similar projects in Oklahoma indicate that labor costs approximate 14 percent of the construction costs. This value for the structure in Lincoln County was amortized as an annual redevelopment benefit. The average annual benefits from this source amounts to \$12,308. The value of local labor employed in project operations and maintenance were treated as a decreasing annuity for 20 years and converted to an annual equivalent over project life. The average annual benefits from this source amounts to \$4,605. The total average annual redevelopment benefits are estimated to be \$12,913.

From a national viewpoint the secondary benefits from this project are not considered to be significant. Locally, secondary benefits including increased business activity and improved economic conditions in the adjoining communities will result from the installation of the complete project. Installation of the structural measures will permit the farmers of the watershed to plan their cropping systems with a reasonable sense of security against flooding. This will tend to stabilize employment in businesses associated with agriculture and promote the economic well being of the inhabitants of the area. The average annual local secondary benefits are estimated to be \$20,258 less 10 percent of reduced production in project sites.

COMPARISON OF BENEFITS AND COSTS

The average annual cost of structural measures (amortized installation cost plus operation and maintenance) is \$148,608. The installation of the structural measures is expected to produce average annual primary benefits of \$238,001. The ratio of primary benefits to cost will be 1.6:1.

Total benefits, including secondary, from structural measures will amount to \$258,259 and will provide \$1.74 for each dollar of cost (table 6).

PROJECT INSTALLATION

Land Treatment Measures

The land treatment measures will be established by farmers and ranchers over an 8-year period in cooperation with the Lincoln County and Shawnee Soil and Water Conservation Districts which are giving technical assistance in the planning and application of these measures under their going program. This assistance will be accelerated with Public Law 566 funds to assure application of the planned measures within the 8-year project installation period.

The governing bodies of the soil and water conservation districts will assume aggressive leadership in accelerating the planned land treatment measures. The landowners and operators within the watershed will be encouraged to apply and maintain soil and water conservation measures on their farms and ranches. District-owned equipment will be made available to the landowners and operators in accordance with existing arrangements for equipment usage in the district. The Soil Conservation Service will provide additional technical assistance to the district to assist landowners and operators in accelerating the planning and application of soil, plant, and water conservation measures.

The soil and water conservation loan program of the Farmers Home Administration is available to all eligible farmers and ranchers in the area. Educational meetings will be held in cooperation with other agencies to outline the services available and eligibility requirements. Present FHA clients will be encouraged to cooperate in the program.

The Oklahoma Department of Wildlife Conservation will assist the Service and the districts by providing technical assistance in planning and promoting the application of fish and wildlife habitat development.

The Extension Service will assist with the educational phase of the program by conducting general information and local farm meetings, prepare radio, television, and press releases, and using other methods of getting information to landowners and operators in the watershed.

Structural Measures

The local sponsors will continue their coordination through the Quapaw Creek Watershed Association which was organized to unite the leadership of the watershed into one group having a common goal. This association will arrange for meetings to fit a definite schedule. This group will agree on action to be taken.

The Lincoln County Soil and Water Conservation District will contract or arrange for the contracting for construction of the 41 single purpose floodwater retarding structures and 8.8 miles of channel improvement within their own district. The Shawnee Soil and Water Conservation District

will contract or arrange for the contracting for construction of site 14. Land easements and rights-of-way, and all road, utilities, or other improvement relocation required by the single purpose structural measures will be provided by the soil and water conservation districts at no cost to the Federal Government.

The town of Sparks will contract for construction of multiple purpose site number 1 and water supply line. The town will furnish land, easements, and rights-of-way, and relocations of utilities and roads at no cost to the Federal Government. The town will also furnish all the cost of construction and installation services allocated to the municipal water supply and all the cost of the water supply line.

The town of Meeker will contract for construction of multiple purpose site 15, water supply line, and associated recreational facilities. Land, easements, and rights-of-way and relocations will be cost-shared with the town portion being 56.4 percent and Public Law 566 funds furnishing 43.6 percent. Flowage easement will be acquired on 30 acres which would have no recreational value, at no cost to the Government. The town will furnish all the construction and installation services cost allocated to the municipal water supply and all the cost of the water supply line. The town will also furnish the local share of funds required for construction cost allocated to recreational water storage and construction cost and installation services for recreational facilities constructed under contract.

The legal fees incurred in acquiring land, easements, and rights-of-way for all structural measures and cost of contract administration will be furnished by the local sponsors.

Construction units were considered with various combinations of structures. It was found that the benefits which would accrue to floodwater structures 12 through 14 and multiple purpose structure 15 (table 7) will, in the absence of the remaining works of improvement of the project, exceed the cost of the structural measures.

All the floodwater retarding structures, 9 through 14, 16 through 39, and multiple purpose structure 15 will be constructed before or concurrently with the channel improvement. When floodwater retarding structures are in series, the upper structure will be constructed before or concurrently with the lower structure.

Federal funds may be provided and construction of planned floodwater retarding structures will be started in the construction unit or in the watershed when the conditions outlined below are met (while construction may begin in the construction unit when requirements are met for the unit, funds will be made available for the remainder of the watershed only when requirements for the entire project are met):

1. Easements and rights-of-way:

- a. All easements and rights-of-way have been obtained on more than 50 percent of the sites in the watershed or construction unit, and
- b. The sponsors have a definite plan to clear the easements on the remainder of the sites in the watershed or construction unit. Funds are on hand which are adequate when used as a revolving fund to clear these sites. The sponsors agree to use the funds and their authority to secure land for the construction of the structures where easements are not granted. Schedules have been developed which show that the remainder of sites can be cleared with the funds available so that construction will continue each year until the project is completed.

2. The sponsors have arranged for contracting.

3. Operation and Maintenance:

- a. A fund for maintenance is established to pay for uncontributed labor, equipment, and supplies.
- b. The approved operation and maintenance agreement outline. How the maintenance will be accomplished and how the funds will be replaced when necessary.

4. Goals are set to meet the following land treatment requirements for the construction of each structure in the unit:

- a. Farm and ranch conservation agreements to carry out recommended soil conservation practices on more than 50 percent of the farm lands in the drainage area above each floodwater retarding structure.
- b. More than 75 percent of the effective land treatment measures above each floodwater retarding structure have been installed, or scheduled to be installed prior to completion of the floodwater retardation structure on those sediment source areas which, if uncontrolled, would require a material increase in the cost of construction and maintenance of the dam.

5. The project is approved and Public Law 566 funds are available.

Technical assistance will be provided by the Soil Conservation Service in planning, designing, preparation of specifications, supervision of construction, preparation of contract payment estimates, final inspections, executions of certificates of completion, and related tasks for the establishment of the planned structural measures for flood prevention and

sediment reduction. The various features of cooperation between the participating parties have been covered in appropriate memoranda of understanding and working agreements.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the structural works of improvement and technical assistance for accelerated land treatment as described in this work plan will be provided under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 69 Stat. 666) as amended.

Federal assistance is contingent upon local organizations meeting their necessary prior obligations and on the appropriation and allotments of Federal funds for these purposes.

The sponsoring organizations recognize their obligations and expected expense and are prepared to carry out their part of project installation.

Individual owners and operators will finance installation of land treatment measures on their land. The county ASC committees will cooperate with the governing bodies of the soil and water conservation districts by selecting and providing financial assistance for those practices which will accomplish the conservation objectives in the shortest possible time. The non-Federal cost of installing structural measures will be financed by the Lincoln County and Shawnee Soil and Water Conservation Districts, and the towns of Sparks and Meeker. Sparks and Meeker are each corporate bodies and have the authority to raise funds through revenue bond elections.

It is expected that 50 percent of the required easements will be contributed by landowners at no cost to the local organizations. Donations by benefited landowners and interested organizations and individuals will be used to set up a local watershed revolving fund for obtaining land rights. State watershed revolving funds will be used as available after 90 percent of the easements are obtained. Both FHA and private sources of credit are also available and may be used if necessary.

The non-Federal costs for the two multiple purpose structures and recreational developments will be financed through use of Farmers Home Administration loans, donations, and supplemented by grants. The towns of Meeker and Sparks have applied for Farmers Home Administration loans.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment Measures

The land treatment measures on privately owned lands will be operated and maintained by the landowners or operators of the farms and ranches on which the measures are installed under agreements with Lincoln County and Shawnee Soil and Water Conservation Districts. Representatives of the districts will make periodic inspections of the land treatment measures to determine maintenance needs and will encourage landowners and operators to perform needed maintenance. District-owned equipment will be made available for this purpose.

Structural Measures

The 42 floodwater retarding structures, 8.8 miles of stream channel improvement and appurtenances will be operated and maintained by the Lincoln County and Shawnee Soil and Water Conservation Districts.

The town of Meeker will operate and maintain multiple purpose site No. 15, the associated recreational development, and the water supply line. The town of Sparks will operate and maintain multiple purpose site No. 1 and the water supply line. The estimated average annual operation and maintenance costs are as follows:

42 Floodwater Retarding Structures and Appurtenances	\$4,315
8.8 Miles of Channel Improvement and Appurtenances	3,084
Multiple Purpose Site No. 1	100
Water Supply Line	1,080
Multiple Purpose Site No. 15	300
Recreational Development for Meeker	4,001
Water Supply Line	2,790
Total	<u>\$15,670</u>

Operation and maintenance costs for the recreational development includes replacement costs of basic facilities, repairing basic facilities, mowing and labor cost associated with keeping the grounds and other miscellaneous work.

Supervisors of the Lincoln County and Shawnee Soil and Water Conservation Districts and the Town Councils of Meeker and Sparks fully understand their obligations for maintenance and will execute specific maintenance agreements prior to the issuance of any invitation to bid. The necessary maintenance work will be accomplished with resources of the soil and water conservation district, and town revenue using contributed labor and equipment, by contract or force account or a combination of these methods.

Structural measures will be inspected by representatives of the local sponsors accompanied by Soil Conservation Service personnel at least annually and after each heavy rain or streamflow.

For the floodwater retarding and multiple purpose structures, items of inspection will include but not be limited to the conditions of the principal spillway and its appurtenances, emergency spillway, pumps, earth fill, vegetative cover of the emergency spillway, fences, and gates installed as a part of the floodwater retarding structures.

For the 8.8 miles of improved channel, items of inspection will include but not be limited to degree of channel scour, channel filling, bank erosion, obstruction to flow (caused by debris located against bridges, fences, and water gates), brush and tree growth within the channel, and the need for control of vegetation or channel clean-out. Inspections of the recreational facilities will include safety, sanitary, and other functional features most likely to require maintenance.

The Soil Conservation Service will participate in the operation and maintenance only to the extent of furnishing technical assistance to aid in inspecting and furnishing technical guidance and information necessary for the operation and maintenance program.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Quapaw Creek Watershed, Oklahoma

Installation Cost		:	:	Number	:	Estimated Cost (dollars)		2/
Item		:	:	to be	:	Public Law		3/ :
		:Unit	:	Applied	:	566 Funds	: Other	: Total
<u>LAND TREATMENT 1/</u>								
Soil Conservation Service								
Cropland	Acre	9,355	-			84,750		84,750
Grassland	Acre	55,963	-			724,353		724,353
Miscellaneous Lands	Acre	450	-			29,480		29,480
Technical Assistance			64,000			37,736		101,736
SCS Subtotal			64,000			876,319		940,319
TOTAL LAND TREATMENT			64,000			876,319		940,319
<u>STRUCTURAL MEASURES</u>								
Soil Conservation Service								
Floodwater Retarding Strs.	No.	42	1,839,465			-		1,839,465
Multiple Purpose Structures	No.	2	266,356			85,041		351,397
Basic Recreational Facilities	No.	1	15,326			15,326		30,652
Water Supply Lines	No.	2	-			68,500		68,500
Stream Channel Improvement and Appurtenant Structures	Mile	8.8	449,949			-		449,949
Subtotal - Construction			2,571,096			168,867		2,739,963
<u>Installation Services</u>								
Soil Conservation Service								
Engineering Services			468,145			21,325		489,470
Other			189,458			5,667		195,125
Subtotal - Installation Services			657,603			26,992		684,595
<u>Other Costs</u>								
Land, Easements, and R/W			72,000			545,095		617,095
Administration of Contracts			-			16,400		16,400
Subtotal - Other			72,000			561,495		633,495
TOTAL STRUCTURAL MEASURES			3,300,699			757,354		4,058,053
TOTAL PROJECT			3,364,699			1,633,673		4,998,372

1/ No Federal land included.

2/ Includes reimbursement from ACPS and other Federal funds under going program.

3/ Price Base - 1963

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TABLE 1A - STATUS OF WATERSHED WORKS OF IMPROVEMENT

1/
Quapaw Creek Watershed, Oklahoma

Measures	: Unit :	: Number Applied : to Date	: Total Cost <u>2/</u> (dollars)
<u>LAND TREATMENT</u>			
Soil Conservation Service			
Conservation Cropping System	Acre	7,625	45,750
Contour Farming	Acre	1,374	1,374
Cover and Green Manure Crops	Acre	5,356	48,204
Crop Residue Use	Acre	5,615	8,424
Grasses and Legumes in Rotation	Acre	2,628	10,512
Pasture and Hayland Planting	Acre	5,899	118,100
Proper Use (Pasture & Range)	Acre	25,360	25,360
Range Deferred Grazing	Acre	13,957	20,925
Land Clearing	Acre	244	11,200
Critical Area Planting	Acre	154	15,400
Diversions	Mile	13	7,997
Waterway Development	Acre	0.9	108
Pond Construction	Number	346	121,100
Terracing	Mile	17	7,085
Fish Pond Stocking	Number	48	1,440
TOTAL LAND TREATMENT			442,979

1/ No Federal land included.2/ Price Base: 1963

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TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION
Quapaw Creek Watershed, Oklahoma
(Dollars) 1/

Structure Site Number	Installation Cost - Public Law 566				Installation Cost - Other Funds				Total	
	: Construc- tion	: Installation Services : Engineering	: Easements : and R/W	: Total Public : Law 566	: Construc- tion	: Installation Services : Engineering	: Easements : and R/W	: Total	: Installation Cost	: Installation Cost
Floodwater Retarding										
2	36,267	7,254	-	46,390	-	-	300	1,700	2,000	48,390
3	62,667	12,533	-	80,163	-	-	300	22,820	23,120	103,283
4	38,635	7,727	-	49,418	-	-	300	10,075	10,375	59,793
5	26,950	5,390	-	34,476	-	-	300	2,475	2,775	37,251
6	43,118	8,624	-	55,153	-	-	300	2,500	2,800	57,953
7	25,520	5,104	-	32,647	-	-	300	1,500	1,800	34,447
8	52,424	10,485	-	67,056	-	-	300	11,205	11,505	78,561
9	36,810	7,362	-	47,084	-	-	300	1,205	1,505	48,589
10	63,177	12,635	-	80,810	-	-	300	5,260	5,560	86,370
11	66,033	13,207	-	84,469	-	-	300	16,575	16,875	101,344
12	36,552	7,310	-	46,754	-	-	300	1,480	1,780	48,534
13	47,409	9,482	-	60,641	-	-	300	3,195	3,495	64,136
14	56,353	11,270	-	72,081	-	-	300	8,890	9,190	81,271
16	31,020	6,204	-	39,683	-	-	300	3,905	4,205	43,888
17	35,415	7,083	-	45,300	-	-	300	4,130	4,430	49,730
18	40,611	8,122	-	51,946	-	-	300	7,130	7,430	59,376
19	49,865	9,973	-	63,783	-	-	300	9,040	9,340	73,123
20	40,016	8,003	-	51,185	-	-	300	5,290	5,590	56,775
21	34,976	6,995	-	44,738	-	-	300	3,775	4,075	48,813
22	32,780	6,556	-	41,935	-	-	300	2,885	3,185	45,120
23	53,561	10,712	-	68,510	-	-	300	9,230	9,530	78,040
24	36,527	7,305	-	46,722	-	-	300	1,635	1,935	48,657
25	58,059	11,612	-	74,264	-	-	300	6,030	6,330	80,594
26	70,043	14,009	-	89,599	-	-	300	13,630	13,930	103,529
27	44,695	8,939	-	57,170	-	-	300	5,845	6,145	63,315
28	39,783	7,957	-	50,887	-	-	300	7,390	7,690	58,577
29	28,600	5,720	-	36,587	-	-	300	3,715	4,015	40,602
30	43,583	8,717	-	55,748	-	-	300	10,480	10,780	66,528
31	58,524	11,705	-	74,859	-	-	300	28,660	28,960	103,819
32	59,994	11,999	-	76,744	-	-	300	7,880	8,180	84,924
33	35,104	7,020	-	44,901	-	-	300	2,990	3,290	48,191
34	37,224	7,445	-	47,614	-	-	300	2,905	3,205	50,819
35	38,698	7,739	-	49,498	-	-	300	5,120	5,420	54,918
36	38,720	7,744	-	49,533	-	-	300	3,535	3,835	53,368
37	32,285	6,457	-	41,301	-	-	300	5,450	5,750	47,051
38	26,015	5,203	-	33,280	-	-	300	2,785	3,085	36,365
39	33,550	6,710	-	42,920	-	-	300	3,800	4,100	47,020
40	52,243	10,449	-	66,825	-	-	300	4,405	4,705	71,530
41	88,110	17,622	-	112,710	-	-	300	23,230	23,530	136,240

TABLE 2 - ESTIMATED STRUCTURE COST DISTRIBUTION (continued)
(Quapaw Creek Watershed, Oklahoma
(Dollars) 1/

Structure Site Number	Installation Cost - Public Law 566			Installation Cost - Other Funds			Total		
	Construction	Installation Services	Easements	Construction	Installation Services	Easements	Construction	Installation Services	Easements
	Other	Engineering	and R/W	Other	Engineering	and R/W	Other	Engineering	and R/W
Floodwater Retarding Structures									
42	30,690	6,138	-	39,261	-	-	300	4,235	4,535
43	50,459	10,092	-	64,543	-	-	300	8,760	9,060
44	26,400	5,280	-	33,773	-	-	300	2,990	3,290
Subtotal	1,839,465	367,893	145,603	2,352,961	-	-	12,600	289,735	302,335
Multiple Purpose									
Structure #1 3/	44,890	8,080	3,225	56,195	27,037	4,867	500	11,300	45,646
Pumping Station and Water Supply Line									
Subtotal	44,890	8,080	3,225	56,195	6,000	480	300	240	7,020
Multiple Purpose									
Structure #15 4/	221,466	42,110	13,975	349,551	33,037	5,347	800	11,300	52,666
Pumping Station & Water Supply Line									
Subtotal	221,466	42,110	13,975	349,551	58,004	8,195	700	97,600	167,218
Basic Recreational Facilities									
Subtotal	15,326	1,533	766	17,625	62,500	6,250	1,500	1,000	71,250
Stream Channel Improvement									
Dike	414,604	41,460	23,089	479,153	15,326	1,533	300	766	17,925
Grade Stabilization	2,345	469	186	3,000	135,830	15,978	2,500	3,485	256,393
Structure #101	33,000	6,600	2,614	42,214	-	-	100	-	100
Subtotal	449,949	48,529	25,889	524,367	-	-	500	145,460	145,960
GRAND TOTAL	2,571,096	468,145	189,458	3,300,699	168,867	21,325	5,667	16,400	545,095
									757,354
									4,058,053

- 1/ Price Base 1963.
2/ Cost includes outlet channel.
3/ Flood Prevention and Municipal Water Supply.
4/ Flood Prevention, Recreation, and Municipal Supply
5/ Includes flowage easement \$1,500 and legal fees \$3,000.
6/ Includes easements, rights-of-way and legal fees.

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TABLE 2A - COST ALLOCATION AND COST SHARING SUMMARY

Quapaw Creek Watershed, Oklahoma

1/
(Dollars)

	PURPOSE				
	Flood pre-	Munici-	Recrea-		
Item	vention	pal	tion		Total
<u>COST ALLOCATION</u>					
Single Purpose					
Structures 2 through 14, and 16 through 44	2,655,296	0	0		2,655,296
Stream Channel Improvement	670,327	0	0		670,327
Water Supply Lines <u>2/</u>	0	78,270	0		78,270
Recreational Facilities	0	0	35,550		35,550
Multiple Purpose Structures					
1	56,195	45,646	0		101,841
15	259,090	80,890	176,789		516,769
<u>Total</u>	<u>3,640,908</u>	<u>204,806</u>	<u>212,339</u>		<u>4,058,053</u>
<u>COST SHARING</u>					
Public Law 566	3,192,613	0	108,086		3,300,699
Other	448,295	204,806	104,253		757,354
<u>Total</u>	<u>3,640,000</u>	<u>204,806</u>	<u>212,339</u>		<u>4,058,053</u>

1/ Price Base: 19632/ Water Supply Lines for sites 1 and 15.

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TABLE 2B - BASIC RECREATIONAL FACILITIES

Quapaw Creek Watershed, Oklahoma

Site 15

Item	Unit	Number	Unit Cost (dollars)	Cost (dollars)
1. Roads, gravel	mile	3.5	3,000	10,500
2. Foot paths	mile	2.5	500	1,250
3. Parking areas	acre	2	1,000	2,000
4. Picnic tables (concrete)	number	20	100	2,000
5. Fireplaces (grills)	number	10	100	1,000
6. Boat ramps (concrete)	number	1	1,000	1,000
7. Toilets <u>1</u> /	number	1	3,000	3,000
8. Water wells <u>1</u> /	number	1	1,200	1,200
9. Fencing & cattle guards	mile	8	900	7,200
10. Grass and tree plantings	acre	12	100	1,200
11. Picnic arbors	number	1	1,500	1,500
12. Boat docks	number	1	2,250	2,250
13. Lighting systems	number	1	1,150	1,150
TOTAL				35,250

1/ Final designs and location to be approved by the State Health Department.

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**TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
AND MULTIPLE PURPOSE STRUCTURES**

Quapaw Creek Watershed, Oklahoma

Item	Unit	STRUCTURE NUMBERS				
		1	2	3	4	5
Drainage Area <u>1/</u>	Sq.Mi.	0.58	1.13	4.30	1.13	0.69
Storage Capacity <u>1/</u>						
Sediment Pool (50-yr.)	Ac.Ft.	-	36	135	31	21
Sediment Reserve	Ac.Ft.	31	35	138	34	24
Recreation Pool	Ac.Ft.	-	-	-	-	-
Municipal Pool	Ac.Ft.	150	-	-	-	-
Sediment in Recreation Pool	Ac.Ft.	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	8	6	20	9	6
Sediment in Municipal Pool	Ac.Ft.	10	-	-	-	-
Detention Pool	Ac.Ft.	200	286	1,055	287	176
Total	Ac.Ft.	399	363	1,348	361	227
Surface Area <u>1/</u>						
Sediment Pool (50-yr.)	Acre	-	6	42	10	6
Sed. Reserve Pool	Acre	4	10	58	14	12
Recreation Pool	Acre	-	-	-	-	-
Municipal Pool	Acre	16	-	-	-	-
Detention Pool	Acre	26	30	127	45	29
Volume of Fill	Cu.Yd.	81,100	51,000	104,400	60,900	33,000
Elevation Top of Dam <u>1/</u>	Foot	816.7	863.6	853.1	886.9	887.9
Elevation Recreation Pool	Foot	-	-	-	-	-
Elevation Municipal Pool	Foot	802.4	-	-	-	-
Maximum Height of Dam <u>1/</u>	Foot	42	41	37	29	28
Emergency Spillway						
Crest Elevation <u>1/</u>	Foot	812.6	860.1	849.1	883.4	885.4
Bottom Width <u>1/</u>	Foot	52	60	124	50	82
Type		Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use <u>3/</u>		2	4	4	4	4
Average Curve No. - Future Cond. II		76	76	76	77	77
Emergency Spillway Hydrograph						
Storm Rainfall (6-hour)	Inch	9.78	6.43	6.40	6.45	6.52
Storm Runoff	Inch	6.80	3.75	3.73	3.88	3.94
Velocity of Flow (Vc) <u>4/</u>	Ft./Sec.	2.5	-	-	-	-
Discharge Rate <u>4/</u>	C.F.S.	9	-	-	-	-
Maximum Water Surface Elev. <u>1/4/</u>	Foot	812.8	-	-	-	-
Freeboard Hydrograph						
Storm Rainfall (6-hour)	Inch	20.40	13.64	13.05	13.67	13.82
Storm Runoff	Inch	17.05	10.47	9.90	10.64	10.79
Velocity of Flow (Vc) <u>4/</u>	Ft./Sec.	8.9	8.0	8.7	8.0	6.5
Discharge Rate <u>4/</u>	C.F.S.	1,080	960	2,393	768	691
Maximum Water Surface Elev. <u>1/4/</u>	Foot	816.7	863.6	853.1	886.9	887.9
Principal Spillway Capacity	C.F.S.	12	10	37	10	6
Capacity Equivalents <u>1/</u>						
Sediment Pool	Inch	-	0.59	0.59	0.52	0.58
Sediment Reserve	Inch	1.02	0.59	0.60	0.56	0.63
Recreation Pool	Inch	-	-	-	-	-
Municipal Pool	Inch	4.86	-	-	-	-
Sediment in Detention Pool	Inch	0.26	0.09	0.09	0.15	0.17
Sediment in Recreation Pool	Inch	-	-	-	-	-
Sediment in Municipal Pool	Inch	0.34	-	-	-	-
Detention Volume	Inch	6.49	4.75	4.60	4.77	4.79
Spillway Storage	Inch	3.53	1.92	2.33	3.00	2.05
Class of Structure		B	A	A	A	A

(See Footnotes last page Table 3).

**TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
AND MULTIPLE PURPOSE STRUCTURES - continued**

Quapaw Creek Watershed, Oklahoma

Item	Unit	STRUCTURE NUMBERS				
		6	7	8	9	10
Drainage Area <u>1/</u>	Sq.Mi	0.69	0.60	2.72	0.73	2.61
Storage Capacity <u>1/</u>						
Sediment Pool (50-yr.)	Ac.Ft.	22	19	71	20	79
Sediment Reserve	Ac.Ft.	23	20	76	21	78
Recreation Pool	Ac.Ft.	-	-	-	-	-
Municipal Pool	Ac.Ft.	-	-	-	-	-
Sediment in Recreation Pool	Ac.Ft.	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	6	5	20	5	13
Sediment in Municipal Pool	Ac.Ft.	-	-	-	-	-
Detention Pool	Ac.Ft.	239	153	925	186	651
Total	Ac.Ft.	290	197	1,092	232	821
Surface Area <u>1/</u>						
Sediment Pool (50-yr.)	Acre	6	6	22	5	15
Sed. Reserve Pool	Acre	10	9	39	9	24
Recreation Pool	Acre	-	-	-	-	-
Municipal Pool	Acre	-	-	-	-	-
Detention Pool	Acre	30	26	99	20	64
Volume of Fill	Cu.Yd.	60,000	31,400	71,600	50,600	94,000
Elevation Top of Dam <u>1/</u>	Foot	947.1	913.5	911.8	904.6	923.5
Elevation Recreation Pool	Foot	-	-	-	-	-
Elevation Municipal Pool	Foot	-	-	-	-	-
Maximum Height of Dam <u>1/</u>	Foot	35	25	34	33	44
Emergency Spillway						
Crest Elevation <u>1/</u>	Foot	943.6	910.7	907.3	902.1	919.5
Bottom Width <u>1/</u>	Foot	88	52	180	108	104
Type	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use <u>3/</u>		2	4	2	4	4
Average Curve No. - Future Cond. II		77	77	77	77	77
Emergency Spillway Hydrograph						
Storm Rainfall (6-hour)	Inch	9.76	6.54	9.39	6.51	6.40
Storm Runoff	Inch	6.90	3.95	6.56	3.93	3.83
Velocity of Flow (Vc) <u>4/</u>	Ft./Sec.	3.3	-	3.0	-	-
Discharge Rate <u>4/</u>	C.F.S.	88	-	138	-	-
Maximum Water Surface Elev. <u>1/</u> <u>4/</u>	Foot	943.9	-	907.8	-	-
Freeboard Hydrograph						
Storm Rainfall (6-hour)	Inch	20.35	13.84	19.48	13.81	13.25
Storm Runoff	Inch	17.15	10.81	16.30	10.78	10.24
Velocity of Flow (Vc) <u>4/</u>	Ft./Sec.	8.0	7.0	9.3	6.5	8.7
Discharge Rate <u>4/</u>	C.F.S.	1,380	549	4,327	901	2,048
Maximum Water Surface Elev. <u>1/</u> <u>4/</u>	Foot	947.1	913.5	911.8	904.6	923.5
Principal Spillway Capacity	C.F.S.	6	5	23	6	22
Capacity Equivalents <u>1/</u>						
Sediment Pool	Inch	0.59	0.60	0.49	0.52	0.57
Sediment Reserve	Inch	0.63	0.64	0.52	0.54	0.56
Recreation Pool	Inch	-	-	-	-	-
Municipal Pool	Inch	-	-	-	-	-
Sediment in Detention Pool	Inch	0.16	0.17	0.14	0.14	0.09
Sediment in Recreation Pool	Inch	-	-	-	-	-
Sediment in Municipal Pool	Inch	-	-	-	-	-
Detention Volume	Inch	6.49	4.79	6.38	4.79	4.68
Spillway Storage	Inch	3.73	2.60	3.27	1.51	2.10
Class of Structure		B	A	B	A	A

(See Footnotes last page Table 3).

**TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
AND MULTIPLE PURPOSE STRUCTURES - continued**

Quapaw Creek Watershed, Oklahoma

STRUCTURE NUMBERS										
11 :	12 :	13 :	14 :	15 :	16 :	17 :	18 5/ :	19 :	20 :	21
3.98	0.50	1.34	2.53	11.42	0.50	1.00	2.22	2.54	1.83	1.33
127	18	48	84	-	18	33	71	80	60	45
138	19	51	90	560	19	36	76	80	64	48
-	-	-	-	548	-	-	-	-	-	-
-	-	-	-	1,000	-	-	-	-	-	-
-	-	-	-	67	-	-	-	-	-	-
36	3	13	25	104	5	10	20	24	16	13
-	-	-	-	121	-	-	-	-	-	-
981	224	337	491	3,739	128	255	554	635	460	335
1,282	264	449	690	6,139	170	334	721	819	600	441
31	3	14	22	-	5	7	18	21	17	12
49	5	23	33	117	8	13	28	33	25	18
-	-	-	-	176	-	-	-	-	-	-
-	-	-	-	250	-	-	-	-	-	-
124	29	55	85	421	22	35	89	83	65	47
100,500	54,200	76,800	90,900	280,000	36,900	50,700	62,600	83,700	62,500	51,700
910.9	940.2	914.0	944.5	925.2	896.9	911.4	972.7	974.2	978.1	949.9
-	-	-	-	903.0	-	-	-	-	-	-
-	-	-	-	908.3	-	-	-	-	-	-
36	42	31	32	46	25	33	34	32	32	34
906.9	936.2	911.5	941.0	919.7	894.4	907.9	968.7	970.2	974.1	946.4
120	114	154	154	292	62	54	50	64	56	64
Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
4	1	4	4.7	2	4	4	4	4	4	4
77	77	77	76	77	77	77	77	77	77	77
6.40	13.15	6.40	6.40	9.18	6.56	6.45	6.29	6.40	6.40	6.41
3.83	10.14	3.83	3.73	6.36	3.97	3.88	3.73	3.83	3.83	3.84
-	4.0	-	-	3.2	-	-	-	-	-	-
-	220	-	-	333	-	-	-	-	-	-
-	936.6	-	-	920.5	-	-	-	-	-	-
13.05	32.88	13.57	13.28	18.91	13.91	13.70	13.35	13.25	13.45	13.58
10.04	29.54	10.54	10.12	15.74	10.87	10.67	10.32	10.23	10.42	10.55
8.7	8.7	6.5	8.0	10.3	6.5	8.0	8.7	8.7	8.7	8.0
2,366	2,215	1,289	2,409	9,600	532	857	978	1,258	1,090	1,019
910.9	940.2	914.0	944.5	925.2	896.9	911.4	972.7	974.2	978.1	949.9
34	5	11	21	97	4	8	19	22	16	11
0.60	0.70	0.67	0.62	-	0.67	0.62	0.60	0.59	0.61	0.63
0.65	0.70	0.72	0.67	0.92	0.72	0.67	0.64	0.59	0.66	0.68
-	-	-	-	0.90	-	-	-	-	-	-
-	-	-	-	1.64	-	-	-	-	-	-
0.17	0.11	0.19	0.19	0.17	0.19	0.18	0.17	0.18	0.17	0.18
-	-	-	-	0.11	-	-	-	-	-	-
-	-	-	-	0.20	-	-	-	-	-	-
4.62	8.39	4.71	3.64	6.14	4.79	4.79	4.68	4.69	4.71	4.73
2.76	5.50	2.16	2.54	4.17	2.28	2.54	3.41	3.20	3.15	2.61
A	C	A	A	B	A	A	A	A	A	A

(See Footnotes last page Table 3)

**TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
AND MULTIPLE PURPOSE STRUCTURES - continued**

Quapaw Creek Watershed, Oklahoma

Item	Unit	STRUCTURE NUMBERS				
		22	23	24	25	26
Drainage Area <u>1/</u>	Sq.Mi.	1.12	2.69	0.90	2.84	4.37
Storage Capacity <u>1/</u>						
Sediment Pool (50-yr.)	Ac.Ft.	41	88	33	86	144
Sediment Reserve	Ac.Ft.	44	91	35	94	152
Recreation Pool	Ac.Ft.	-	-	-	-	-
Municipal Pool	Ac.Ft.	-	-	-	-	-
Sediment in Recreation Pool	Ac.Ft.	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	11	25	10	24	42
Sediment in Municipal Pool	Ac.Ft.	-	-	-	-	-
Detention Pool	Ac.Ft.	284	911	230	709	1,074
Total	Ac.Ft.	380	1,115	308	913	1,412
Surface Area <u>1/</u>						
Sediment Pool (50-yr.)	Acre	11	24	7	17	32
Sed. Reserve Pool	Acre	18	37	10	28	49
Recreation Pool	Acre	-	-	-	-	-
Municipal Pool	Acre	-	-	-	-	-
Detention Pool	Acre	50	120	28	76	119
Volume of Fill	Cu.Yd.	44,600	90,800	57,900	97,400	123,700
Elevation Top of Dam <u>1/</u>	Foot	927.8	963.2	1002.4	984.2	985.7
Elevation Recreation Pool	Foot	-	-	-	-	-
Elevation Municipal Pool	Foot	-	-	-	-	-
Maximum Height of Dam <u>1/</u>	Foot	28	35	38	39	43
Emergency Spillway						
Crest Elevation <u>1/</u>	Foot	924.4	959.2	999.2	980.7	981.7
Bottom Width <u>1/</u>	Foot	50	174	52	114	120
Type		Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use <u>3/</u>		4	2	4	4	4
Average Curve No. - Future Cond. II		77	75	75	75	75
Emergency Spillway Hydrograph						
Storm Rainfall (6-hour)	Inch	6.45	9.35	6.47	6.40	6.40
Storm Runoff	Inch	3.88	6.27	3.69	3.62	3.62
Velocity of Flow (Vc) <u>4/</u>	Ft./Sec.	-	3.0	-	-	-
Discharge Rate <u>4/</u>	C.F.S.	-	109	-	-	-
Maximum Water Surface Elev. <u>1/</u> <u>4/</u>	Foot	-	959.4	-	-	-
Freeboard Hydrograph						
Storm Rainfall (6-hour)	Inch	13.67	19.48	13.70	13.21	13.05
Storm Runoff	Inch	10.64	15.98	10.38	9.90	9.75
Velocity of Flow (Vc) <u>4/</u>	Ft./Sec.	7.9	8.7	7.7	8.0	8.7
Discharge Rate <u>4/</u>	C.F.S.	726	3,417	697	1,786	2,373
Maximum Water Surface Elev. <u>1/</u> <u>4/</u>	Foot	927.8	963.2	1002.4	984.2	985.7
Principal Spillway Capacity	C.F.S.	9	23	8	24	37
Capacity Equivalents <u>1/</u>						
Sediment Pool	Inch	0.69	0.61	0.69	0.57	0.62
Sediment Reserve	Inch	0.73	0.64	0.73	0.62	0.65
Recreation Pool	Inch	-	-	-	-	-
Municipal Pool	Inch	-	-	-	-	-
Sediment in Detention Pool	Inch	0.20	0.17	0.20	0.16	0.18
Sediment in Recreation Pool	Inch	-	-	-	-	-
Sediment in Municipal Pool	Inch	-	-	-	-	-
Detention Volume	Inch	4.75	6.35	4.79	4.68	4.61
Spillway Storage	Inch	3.23	3.91	2.14	1.89	2.24
Class of Structure		A	B	A	A	A

(See Footnotes last page Table 3).

**TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
AND MULTIPLE PURPOSE STRUCTURES - continued**

Quapaw Creek Watershed, Oklahoma

STRUCTURE NUMBERS								
27	28	29	30	31 2/	32 5/	33	34	35
1.38	1.41	0.83	2.97	4.86	2.64	0.90	0.90	0.96
43	57	32	124	205	110	37	37	36
45	61	35	131	225	117	40	40	39
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
12	17	10	35	60	31	11	11	10
-	-	-	-	-	-	-	-	-
347	355	212	741	777	659	230	230	246
447	490	289	1,031	1,267	917	318	318	331
9	18	7	25	55	18	9	10	10
17	26	13	42	83	30	16	15	17
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
49	56	33	103	174	72	37	35	38
72,100	57,800	39,200	70,300	78,100	103,400	53,200	54,100	58,900
977.5	966.9	947.8	945.6	902.2	959.8	932.5	935.4	903.0
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
30	23	33	38	22	36	29	29	27
974.5	963.7	944.8	941.6	898.7	955.8	929.4	932.2	900.5
86	65	50	60	300	94	52	52	104
Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
4	4	4	4	4-10	4	4	4	4
75	75	75	75	75	75	75	75	75
6.40	6.40	6.48	6.40	6.40	6.40	6.47	6.47	6.46
3.62	3.62	3.69	3.62	3.62	3.62	3.68	3.68	3.67
-	-	-	-	2.9	-	-	-	-
-	-	-	-	180	-	-	-	-
-	-	-	-	899.1	-	-	-	-
13.57	13.55	13.74	13.18	13.05	13.05	13.72	13.72	13.70
10.25	10.23	10.42	9.87	9.75	9.75	10.40	10.40	10.38
7.3	7.6	7.3	8.7	8.0	8.7	7.4	7.6	6.5
1,033	884	610	1,145	4,610	1,718	667	709	875
977.5	966.9	947.8	945.6	902.2	959.8	932.5	935.4	903.0
12	12	7	25	112	22	8	8	8
0.58	0.76	0.73	0.78	0.79	0.78	0.78	0.78	0.71
0.61	0.81	0.79	0.83	0.87	0.83	0.83	0.83	0.76
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
0.16	0.22	0.21	0.22	0.23	0.22	0.22	0.22	0.20
-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-
4.72	4.72	4.79	4.68	3.00	4.68	4.79	4.79	4.79
2.36	2.74	2.58	2.99	2.74	2.14	2.53	2.50	1.89
A	A	A	A	A	A	A	A	A

(See Footnotes last page Table 3).

**TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
AND MULTIPLE PURPOSE STRUCTURES - continued**

Quapaw Creek Watershed, Oklahoma

Item	Unit	STRUCTURE NUMBERS				
		36	37	38	39	40
Drainage Area <u>1/</u>	Sq.Mi.	0.74	0.88	0.72	1.20	1.33
Storage Capacity <u>1/</u>						
Sediment Pool (50-yr.)	Ac.Ft.	32	37	30	47	53
Sediment Reserve	Ac.Ft.	34	39	31	51	57
Recreation Pool	Ac.Ft.	-	-	-	-	-
Municipal Pool	Ac.Ft.	-	-	-	-	-
Sediment in Recreation Pool	Ac.Ft.	-	-	-	-	-
Sediment in Detention Pool	Ac.Ft.	9	10	8	13	15
Sediment in Municipal Pool	Ac.Ft.	-	-	-	-	-
Detention Pool	Ac.Ft.	189	225	184	304	337
Total	Ac.Ft.	264	311	253	415	462
Surface Area <u>1/</u>						
Sediment Pool (50-yr.)	Acre	8	10	7	9	11
Sed. Reserve Pool	Acre	13	18	13	17	17
Recreation Pool	Acre	-	-	-	-	-
Municipal Pool	Acre	-	-	-	-	-
Detention Pool	Acre	30	37	33	46	45
Volume of Fill	Cu.Yd.	54,900	42,400	32,300	48,000	80,300
Elevation Top of Dam <u>1/</u>	Foot	893.9	940.6	949.4	897.8	865.8
Elevation Recreation Pool	Foot	-	-	-	-	-
Elevation Municipal Pool	Foot	-	-	-	-	-
Maximum Height of Dam <u>1/</u>	Foot	28	28	29	34	38
Emergency Spillway						
Crest Elevation <u>1/</u>	Foot	891.0	937.6	946.2	895.3	862.8
Bottom Width <u>1/</u>	Foot	50	64	40	112	76
Type	Veg.	Veg.	Veg.	Veg.	Veg.	Veg.
Percent Chance of Use <u>3/</u>		4	4	4	4	4
Average Curve No. - Future Cond. II		75	76	76	76	75
Emergency Spillway Hydrograph						
Storm Rainfall (6-hour)	Inch	6.52	6.47	6.51	6.42	6.40
Storm Runoff	Inch	3.73	3.79	3.82	3.75	3.62
Velocity of Flow (Vc) <u>4/</u>	Ft./Sec.	-	-	-	-	-
Discharge Rate <u>4/</u>	C.F.S.	-	-	-	-	-
Max. Water Surface Elev. <u>1/</u> <u>4/</u>	Foot	-	-	-	-	-
Freeboard Hydrograph						
Storm Rainfall (6-hour)	Inch	13.80	13.73	13.81	13.61	13.55
Storm Runoff	Inch	10.47	10.55	10.63	10.44	10.23
Velocity of Flow (Vc) <u>4/</u>	Ft./Sec.	7.1	7.3	7.6	6.5	7.3
Discharge Rate <u>4/</u>	C.F.S.	567	761	523	937	904
Max. Water Surface Elev. <u>1/</u> <u>4/</u>	Foot	893.9	940.6	949.4	897.8	865.8
Principal Spillway Capacity	C.F.S.	6	7	6	10	11
Capacity Equivalents <u>1/</u>						
Sediment Pool	Inch	0.81	0.78	0.77	0.74	0.75
Sediment Reserve	Inch	0.86	0.83	0.81	0.79	0.80
Recreation Pool	Inch	-	-	-	-	-
Municipal Pool	Inch	-	-	-	-	-
Sediment in Detention Pool	Inch	0.23	0.22	0.22	0.21	0.21
Sediment in Recreation Pool	Inch	-	-	-	-	-
Sediment in Municipal Pool	Inch	-	-	-	-	-
Detention Volume	Inch	4.79	4.79	4.79	4.75	4.75
Spillway Storage	Inch	2.51	2.38	3.01	2.51	2.29
Class of Structure		A	A	A	A	A

(See Footnotes last page Table 3).

TABLE 3 - STRUCTURE DATA - FLOODWATER RETARDING STRUCTURES
AND MULTIPLE PURPOSE STRUCTURES - continued

Quapaw Creek Watershed, Oklahoma

STRUCTURE NUMBERS				:	
41	42	43	44	:	TOTAL
6.79	0.73	1.88	0.73		88.14
210	27	58	22		2,607
221	28	62	22		3,355
-	-	-	-		548
-	-	-	-		1,150
-	-	-	-		67
58	7	16	4		816
-	-	-	-		131
1,662	187	471	186		23,047
2,151	249	607	234		31,721
55	10	14	6		650
83	16	24	10		1,153
-	-	-	-		176
-	-	-	-		264
194	38	64	31		3,059
139,100	43,800	77,400	32,000		3,140,200
860.4	837.2	864.1	835.9		
-	-	-	-		
-	-	-	-		
37	19	37	30		
856.4	834.7	860.1	833.2		
174	66	54	60		
Veg.	Veg.	Veg.	Veg.		
4	4	4	4		
76	75	75	75		
6.40	6.52	6.40	6.52		
3.73	3.73	3.62	3.73		
-	-	-	-		
-	-	-	-		
-	-	-	-		
13.05	13.80	13.43	13.80		
9.90	10.47	10.12	10.47		
8.7	6.5	8.7	6.8		
3,418	556	1,069	580		
860.4	837.2	864.1	835.9		
102	6	16	6		
0.58	0.69	0.58	0.57		
0.61	0.72	0.62	0.57		
-	-	-	-		
-	-	-	-		
0.16	0.19	0.16	0.09		
-	-	-	-		
-	-	-	-		
4.59	4.79	4.70	4.79		
2.46	2.49	2.79	2.38		
A	A	A	A		

1/ Subject to minor adjustments in final design stage. Major changes will require a work plan revision.

2/ Exclusive of watershed from which runoff is controlled by other structures in series.

3/ Based on regional analysis of gaged runoff (in all cases exceeds minimum requirements set forth in Washington Engineering Memorandum SCS-27).

4/ Maximum during passage of hydrograph.

5/ Partially estimated data.

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TABLE 3A - STRUCTURE DATAGRADE STABILIZATION STRUCTURES

Quapaw Creek Watershed, Oklahoma

Site Number	:	:	Earth	:	:	Type
	:	Drop	Fill	:	Concrete	Structure
	:	:	:	:	:	:
		(foot)	(cu.yds.)		(cu.yds.)	
Main Channel Structure 101 Sta. 98+00		9	2,000		200	Weir-Drop

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TABLE 3B - STRUCTURE DATA - CHANNELS

Quapaw Creek Watershed, Oklahoma

Channel Designation	Station Numbering : Station : Station (100 ft) (100 ft)	Water- shed : Area 2/ : Area 1/ (sq.mi.) (sq.mi.)	Required : Channel Capacity 1/ : Capacity 2/ (cfs) (cfs)	Planned : Channel Capacity 1/ : Capacity 2/ (cfs) (cfs)	Average : Average : : Bottom : Side : (feet) (feet)	Depth : (feet)	Average : Average : : Grade : Velocity : (ft/ft) (ft/sec.)	Designed : (ft/sec.)	Volume of Excavation (1,000 cu.yd)
<u>3/</u> Main Channel									
Section 1	38+00 98+00	18.2	1,300	1,299	45	3:1	5.0	0.0017	4.33 87.3
Section 2 <u>4/</u>	98+00 266+00	25.2	1,390	1,394	14	2:1	10.0	0.0009	4.10 414.1
Section 3	266+00 356+00	35.8	1,830	1,823	22	2:1	10.0	0.0009	4.34 212.9
Section 4	356+00 392+00	36.6	2,000	1,985	25	2:1	10.0	0.0009	4.41 55.7

1/ Flood routed 1-year, 6-hour storm, plus release flow from structures.2/ Uncontrolled drainage area at lower end of section.3/ Stream channel improvement consists of clearing and snagging downstream from Station 392+00 to Station 502+77.4/ Main channel structure 101 at Sta. 98+00.

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TABLE 4 - ANNUAL COST

Quapaw Creek Watershed, Oklahoma

(Dollars)

<u>Evaluation Unit</u>	<u>Amortization of Installation Cost 1/</u>	<u>Operation and Maintenance Cost 2/</u>	<u>Total Cost</u>
Floodwater Retarding Structures 2 through 14 and 16 through 44 and outlet channels; Multiple purpose structures 1 and 15; 8.8 miles Stream Channel Improvement, Grade Stabilization Structure and Dike	132,938	15,670	148,608
TOTAL	132,938	15,670	148,608

1/ Based on 1963 price levels, amortized for 100 years at 3-1/8 percent.

2/ Long-term prices, as projected by ARS, September 1957. Includes \$4,301 for minimum basic facilities, of which \$645 is for replacement of these facilities during the project life.

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TABLE 5 - ESTIMATED AVERAGE ANNUAL
FLOOD DAMAGE REDUCTION BENEFITS

Quapaw Creek Watershed, Oklahoma

(Dollars) 1/

Item	: Estimated Average Annual Damage		: Damage
	: Without Project	: With Project	: Reduction Benefit
Floodwater			
Crop and Pasture	108,271	45,735	62,536
Other Agricultural	42,443	9,304	33,139
Nonagricultural (Roads, Bridges, Etc.)	50,263	9,018	41,245
Subtotal	200,977	64,057	136,920
Sediment			
Overbank Deposition	29,693	5,362	24,331
Swamping	3,499	1,746	1,753
Eufaula Lake	281	125	156
Subtotal	33,473	7,233	26,240
Erosion			
Scour	8,454	2,931	5,523
Indirect	24,290	7,422	16,868
TOTAL	267,194	81,643	185,551

1/ Price Base: Long-term, as projected by ARS, September 1957.

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TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Quapaw Creek Watershed, Oklahoma

(Dollars)

Evaluation Unit	AVERAGE ANNUAL BENEFITS 1/										Average Annual Cost 3/	Benefit : Cost Ratio
	Flood Prevention	Incidental Damage	Reduction	Recreation	Supply	Recreation	Secondary	Development	Revel-	Total		
Multiple Purpose Structures Nos. 1 and 15, and Floodwater Retarding Structures Nos. 2 through 14 and 16 through 44 and outlet channels; 8.8 miles Stream Channel Improvement, Grade Stabilization Structure and Dike	6,115	169,668	16,245	33,060	20,258	12,913	258,259	148,608	1.74:1			
GRAND TOTAL	6,115	169,668	16,245	33,060	20,258	12,913	258,259	148,608	1.74:1			

1/ Price Base: Long-term as projected by ARS, September 1957.

2/ In addition, it is estimated that land treatment measures will provide flood damage reduction benefits of \$15,883 annually.

3/ From table 4.

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TABLE 7 - CONSTRUCTION UNITS

Quapaw Creek Watershed, Oklahoma

(Dollars)

Measures in Construction Unit	:	Annual Benefit <u>1/</u>	:	Annual Cost <u>2/</u>
Floodwater Retarding Structures 12 through 14, and Multiple Purpose Structure No. 15	:	65,582	:	34,202

1/ Price Base: Long-term prices as projected by ARS, September 1957.

2/ Derived from amortized installation costs based on 1963 price levels and operation and maintenance costs based on long-term prices as projected by ARS, September 1957.

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INVESTIGATIONS AND ANALYSIS

Land Use and Treatment

Land Treatment Measures

Current conservation needs and amounts of conservation practices applied to date were based on estimates by Soil Conservation Service personnel from records of basic conservation plans on 60 percent of the watershed and on County inventories. Based on the needs and local experience, an estimate was made of the measures that could be applied in the 8-year installation period. The acres to be treated and cost of treatment measures are shown in Table 1. Although needed land treatment measures would have an effect in flood damage reduction, it was apparent that structural measures would be required to attain the degree of flood protection desired.

Soil Cover Conditions

Estimates of the soil cover conditions on the upland area were made from existing work unit records, soil surveys, and studies of geologic formations. Data covering land use of the flood plain were developed during economic investigations.

Engineering Investigations

Structural Measures

After considering the effect of land treatment measures, determination of the needed structural measures was made using the following procedure:

1. A base map of the watershed was prepared showing the watershed boundary, drainage pattern, system of roads, and other pertinent information. Stereoscopic study of consecutive 4-inch aerial photographs was used to locate possible floodwater retarding structure sites and valley cross sections, and to delineate the flood plain. Cross sections were surveyed at selected locations (figure 6) to determine hydraulic characteristics and for flood routing purposes. Data developed from these cross sections were used in computation of peak discharge-damage relations for various flood flows. A map was prepared of the flood plain on which land use, cross section locations, and other information was recorded.
2. A field examination was made of floodwater retarding structure sites previously located stereoscopically. Sites which did not show good storage possibilities or which would inundate highways, utilities, or other expensive improvements, for which relocation was not economically feasible, were relocated or dropped from further consideration. From the remaining sites a system of floodwater retarding structures was selected for further study and detailed survey. Plan of a typical

floodwater structure planned for this watershed is illustrated by plate 1. Alternate systems of structural measures including floodwater retarding structures, drop inlets, outlet channels, and channel improvement were investigated.

3. Topographic maps with 4-ft. contour intervals and a scale of 1 inch - 200 feet were developed from engineering surveys of the pool of each site.

The height of the dams and the size of the pools were determined by the storage volume needed to detain the runoff from the design storm and to provide the additional storage needed for sediment.

Structure data tables were developed to show the drainage area, storage capacity planned for floodwater detention and sediment, release rate of the principal spillway, emergency spillway capacity, area inundated by the pools, and other pertinent data for each structure (Table 3).

Floodwater detention capacity was planned in the structures to detain the expected runoff from a 25-year storm event (class A), 50-year storm event (class B), and 100-year storm event (class C), as determined by a regional analysis of stream gage records in areas of similar geologic formation, topography, and average annual rainfall. Most of the structures are designed to detain temporarily the gaged runoff having a 4 percent chance of occurrence (class A), 2 percent chance of occurrence (class B) and 1 percent chance of occurrence (class C). All detention volumes exceed the minimum requirements set forth in Engineering Memorandum SCS-27.

Embankment volumes were computed assuming $2\frac{1}{2}$ to 1 side slopes, 5 percent consolidation, and a 10-ft. berm on the upstream slope at the top of riser elevation.

Cost estimates were based on computed embankment volumes times a base unit cost. Additional costs for timber clearing, minor rock excavation, outlet channels, and foundation drainage were added on an individual site basis.

The emergency spillways were proportioned by applying appropriate factors to the 6-hour rainfall as shown in Fig. 3.21-1, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, Supplement A. Spillways of sites in series and site 12 (class C) were routed graphically; all other spillways were proportioned by empirical formula.

Principal spillways were designed for an 8.5 c.s.m. release rate except sites 31 and 41, which were designed for 15 c.s.m. release rate.

4. In the study made for improving the 8.8 miles of stream channel, a topographic map on an aerial photograph with scale of 1 inch = 330 feet was made. In addition, intermediate channel cross sections were surveyed between valley cross sections and both were used in volume computations.

The size of the channel was determined by the capacity required to contain the flow produced by the runoff from a 6-hour, 1-year frequency storm with the structures in place. Final design depths were determined by water surface profiles.

Structure data tables were developed showing the drainage area, the required channel capacity, the planned capacity, average bottom width, and other pertinent data for each section of proposed channel (table 3B).

Volume of excavation was computed from the surveyed cross sections. Estimated cost was based on the volume of excavation times a unit cost which allowed for installation of required pipe drops. This cost is shown in Table 2.

5. Costs of structural measures and of land, easements, rights-of-way, and relocation of roads, bridges, pipe lines, and power lines were considered in arriving at the least costly system of measures to accomplish the project objectives.

Operation and maintenance costs of the structures were based on these costs for similar structures installed on other watersheds and projected on a long-term basis. The channel improvement cost was based on cost for mowing and cost of removing sediment.

Hydraulic and Hydrologic Investigations

The following steps were taken as part of the hydrologic investigations and determinations:

1. Basic meteorologic data were tabulated from U. S. Weather Bureau Climatological bulletins and analyzed to determine average precipitation. Precipitation records collected by the U. S. Weather Bureau at Meeker were used to prepare a cumulative departure from normal precipitation graph for Quapaw Creek. These data indicated that 1941 through 1960 was a normal rainfall-runoff period. The recorded events occurring during this period were used to evaluate this project.
2. The present hydrologic cover condition of the watershed was determined by a reconnaissance survey. Soil surveys and geologic conditions were used to determine the hydrologic classification of the soil. The future hydrologic cover condition of the watershed was determined from

information furnished by the work unit conservationists showing the change in land use that could be expected with an accelerated land treatment program during the installation period. Runoff curve numbers for present and future conditions were computed from soil cover complex data.

3. Engineering surveys were made of channel and valley cross sections selected to represent adequately the stream hydraulics and the flood plain area. Preliminary locations for cross sections were made by stereoscopic examination of aerial photographs of the flood plain. The final locations were selected in the field giving due consideration to the needs of the economist and geologist (fig. 6).
4. Cross section rating curves were computed from field survey data collected as described in Item 3 above, by solving water surface profiles for various discharges. The water surface profiles were computed by the use of the IBM 650 computer. Discharge-area inundation curves for total area inundated and for depth increments were plotted from IBM output data for each portion of the valley represented by a cross section.
5. Unit hydrographs were developed and routed using the Improved Co-efficient Method of flood routing (NEH 4, Supplement A, Chapter 17) to determine the volume peak discharge relationship. Area inundated data by incremental depths of flooding were developed by routing volumes of runoff for the historical series using the peak discharge volume relationships. Determinations were made of the area by depth increments that would have been inundated by each storm in the evaluation series under conditions that would exist due to:
 - a. The present condition of the watershed.
 - b. The installation of land treatment measures.
 - c. The installation of land treatment measures and floodwater retarding structures.
 - d. The installation of land treatment measures, floodwater retarding structures, and channel improvement.
6. The surface runoff from the largest storm in historical evaluation flood series was 4.32 inches. This would produce a peak discharge of 28,500 c.f.s. at the reference valley section 8 (fig. 6). After the installation of the land treatment measures proposed in this plan the runoff from this storm would be reduced to 4.20 inches.

After the installation and full functioning of the project, the peak discharge from this storm would be reduced to 7,800 c.f.s. at the reference valley section.

7. An increase in channel capacity was found to be necessary through both Reach 1 and Reach 2 in order to carry the 6-hour, 1-year frequency storm runoff of .52 inches over the drainage area below floodwater retarding structures. This amount of runoff together with release flows from floodwater retarding structures would produce a peak discharge of 1,840 c.f.s. at reference valley section 12 after installation of channel improvement and the planned floodwater retarding structures (fig. 6).
8. The appropriate spillway design storm, and storm pattern, were selected from figures 3.21-1, 3.21-4 and 5, National Engineering Handbook, Section 4, Supplement A, in accordance with criteria contained in Engineering Memorandum SCS-27.

Spillway design and freeboard hydrographs were developed from each of the floodwater retarding structures by the distribution graph method.

All key sites and "C" class structures were graphically routed using the Goodrich flood routing method described on page 5.8-12 of the National Engineering Handbook, Section 5 to check the accuracy of the determination made by the empirical equation.

Reservoir Operation

The reservoir operation studies were made on the multiple purpose reservoirs using the following data:

1. Storage data tables of the Meeker site were developed and plotted as shown in Fig. 4.
2. Storage data tables of the Sparks site were developed and plotted as shown in Fig. 2.
3. The most critical drought period of record (water years 1951 through 1957) was selected for the study.
4. The U. S. Geological Survey gage records on Bellcow Creek and Dry Creek in Lincoln County were used to obtain monthly inflow in acre feet per square mile.
5. The following records were used to compute the net evaporation from the reservoir surface:

- U. S. Weather Bureau Class A pan records at Heyburn Dam.
- U. S. Weather Bureau standard rain gage at Cushing, Oklahoma.
- U. S. Weather Bureau Technical Paper 37.
- U. S. Geological Survey Circular 229 - Water Loss, Investigation, Vol. 1 - Lake Hefner Studies.

6. Monthly future water requirements for the towns of Meeker and Sparks, obtained from the consulting engineers, are shown in the following tabulation:

Project Water Demands

	<u>Meeker, Oklahoma</u>		<u>Sparks, Oklahoma</u>	
	<u>Gallons</u>	<u>Acre Feet</u>	<u>Gallons</u>	<u>Acre Feet</u>
January	2,850,000	8.7	521,000	1.6
February	2,850,000	8.7	587,000	1.8
March	2,850,000	8.7	619,000	1.9
April	5,400,000	16.6	619,000	1.9
May	5,400,000	16.6	880,000	2.7
June	10,800,000	33.1	1,043,000	3.2
July	10,800,000	33.1	1,043,000	3.2
August	10,800,000	33.1	976,000	3.0
September	5,400,000	16.6	717,000	2.2
October	2,850,000	8.7	652,000	2.0
November	2,850,000	8.7	587,000	1.8
December	2,850,000	8.7	521,000	1.6

Meeker Reservoir

The reservoir was operated through the selected study period assuming each purpose individually; recreation, municipal, and with both purposes, to determine the following:

- a. Minimum storage and surface area reached due to loss by evaporation on recreation pool.
- b. Minimum storage reached due to loss by evaporation and use by the town of Meeker.
- c. Minimum storage and surface area of the combined purposes due to loss by evaporation and use by the town of Meeker.

The results of the operations are shown in Figure 5. In March 1957, the municipal pool dipped approximately 587 acre feet down below the storage allocated to recreation. However, if the structure had been built for recreation alone it would have been down approximately 660 acre feet below the maximum allocated to recreation. This verifies the fact that 1,000 acre feet of storage will supply the demands for the town of Meeker without infringing on the storage allocated to recreation, and that the drainage area of this site is sufficient to furnish a suitable yield for both recreation and municipal water supply.

Sparks Reservoir

The reservoir was operated through the selected study period to determine the minimum storage and surface area reached due to loss to evaporation on the municipal pool. The results of these operations are shown in figure 3. In March 1957 the municipal pool would have reached its maximum depletion, but would not have encroached upon the sediment storage.

Sedimentation Investigations

Field investigations of sedimentation problems were made in accordance with the Oklahoma Planning Handbook and Technical Release No. 12, "Procedure for Computing Sediment Requirements for Retarding Reservoirs" (September 1959). This included field examinations along valley cross sections to determine areas of damaging overbank deposition and flood plain scour. Borings were made along approximately 50 percent of the valley cross sections to determine the sediment damage. Conditions of the stream bed and banks also were noted. Findings were prepared in tabular summary for the economist to calculate monetary damage and benefits.

Channel Stability Investigation

A preliminary investigation was made of the proposed channel improvement area. Representative borings were made along the channel, and samples were submitted to the laboratory for analysis to be applied in the tractive force and bed load equations used as a guide in channel design.

The field investigation included 8 borings 12 feet deep. Three representative samples were submitted to the laboratory for analysis. The tests included mechanical analysis, Atterberg limits, soluble salts, and percent dispersion.

Material along the channel bottom is dominantly in moderately heavy CL material. However, at valley sections 12 and 21 of the area to be improved a non-plastic silty sand was encountered.

Channel stability studies were made with Schoklitsch bedload equations and tractive force analysis. The tractive force equation indicates material at valley cross sections 12 and 21 unstable. With the proposed design, therefore, degradation could be expected. However, the Schoklitsch bedload equation indicated the bedload transport capacity of the proposed channel under the design flow-duration is less than the estimated incoming bedload; therefore, channel aggradation will occur. The calculated volume of sediment that will be deposited annually in the channel was used as a basis for estimating annual maintenance (clean-out) costs.

Sediment Source Studies

The Oklahoma Handbook and Technical Release No. 12 were used as references in making field investigations. In accordance with these references, sediment source studies were made by detailed and semi-detailed surveys on

drainage areas above proposed floodwater retarding structures to determine annual gross erosion from all sources. Erosion rates were calculated for separate land areas based on land use, soil unit, slope, and cover condition.

Detail sediment investigations were made of drainage area above 8 floodwater retarding structures, or approximately 33 percent of the total area above sites. From these studies the sediment yield to each structure for the 100-year design storage period was calculated. The remaining 36 sites sediment rates were expanded from the detailed sites.

The total annual amount of sediment deposited in all sites is estimated to be approximately 67 acre feet. The average annual rate of sediment deposited in the structures is estimated to be 0.78 acre foot per square mile. Of the sediment delivered to the structures, approximately 93 percent is from sheet erosion, 1 percent from gully erosion, 1 percent from streambank erosion, and 5 percent from roads. The delivery ratios used for downstream deposition are as follows: sheet erosion 52 percent, roads and gullies 80 percent, and streambank 90 percent. The delivery ratio for sediment to the channel was based on a weighted average from all sources. The delivery ratio from the mouth of Quapaw Creek to Eufaula Lake is approximately 10 percent, based on grain size and flood plain conditions below the mouth.

The upland densities of the soils in place are approximately 90 pounds per cubic foot.

The cross section method of mapping was used to investigate flood plain damage from sediment and scour. Damages were determined by discussing the loss of productivity with landowners, economist, and other technicians.

The reduction in scour damage was determined by the use of hydrologic reductions with land treatment; land treatment and structures; and land treatment, structures and channel. The reduction in sediment from all sources was determined for land treatment, land treatment and structures.

The method used in determining downstream sediment damage was based on texture and depth of sediment deposited over the productive soils.

Geologic Investigations

Preliminary geologic investigations were made at all proposed sites. These investigations included studies of the geologic formations, topography, borrow area, spillway and stream channels.

A Bull Soil Sampler, hand auger, and Brunton compass were used in determining the amount of rock excavation, availability of borrow material, location of emergency spillway and other facts that would affect the cost of floodwater retarding structures.

The Quapaw Creek watershed lies entirely in the Wellington formation (pwa), which consists of resistant and nonresistant sandstone, shales, and a few interbedded limestones.

Geological conditions are similar on all sites and construction problems will be similar. Some rock excavation will be expected in 40 percent of the sites.

Foundation drains may be needed at a few locations. Sufficient fill material is present in the sediment pool area of most sites. Detailed investigations were supplied to the engineer in estimating construction cost.

Economic Investigations

Damage schedules covering 64 percent of the flood plain of the watershed were obtained from landowners and operators in the area. These schedules covered land use and crop distribution, yield data, and historical information on flooding and flood damages. Analysis of the information contained in the schedules and supplemental data from other similar watersheds formed the basis for determining damage rates for depth and season of flooding. In calculating crop and pasture damages, expenses saved, such as the cost of harvesting, were deducted from the gross damage. The applicable damage rates were applied to the floods of the historical series. The damage was adjusted to account for the effect of recurrent flooding when more than one event occurred within a single crop year.

The flood plain land use was mapped in the field. Estimates of normal yields were based on data obtained from the schedules, supplemented by information obtained from soil technicians and other agricultural workers in the area. Due to differences found in the land use and flood frequencies between the upper and lower parts of the watershed, the flood plain was divided into three evaluation reaches.

The monetary value of the physical damage to the flood plain from scour and deposition of sediment was based on the value of production lost. This estimate took into account the lag in recovery of productivity and the cost of farm operations.

Damage to other agricultural property, such as fences, livestock, levees, and farm equipment was estimated from analysis of schedules, using costs prevailing in that area, correlated with sizes of floods.

Damage to roads and bridges is the main item of nonagricultural damage in this watershed. The county commissioner and other residents of the watershed supplied information on these damages. Other nonagricultural damage was to railroads and oil field installations.

Indirect damages were estimated to be 10 percent of the direct floodwater damages.

Floodwater, scour, and sediment damages were calculated under conditions without project and with project. The difference between average annual damages at the time of initiation of the project and those expected after its installation constitutes the benefit assigned to land treatment and structural measures.

Benefits from reduction of crop and pasture damages and flood plain scour resulted from the combined effects of reduction in area inundated and reduced depth of inundation. Estimated reduction in the rate of sediment production and in acreage flooded after installation of the project account for benefits from reduction of valley sediment damage.

Areas that will be inundated by the sediment and detention pools of floodwater retarding structures were excluded from the damage appraisal. Production lost in these areas after installation of the project was compared with the appraised value of the sites. In this analysis, it was considered that there would be no production in the sediment pools. The land covered by the detention pools was assumed to be converted to grassland under project conditions. Since the value of the easement exceeded the value of production lost, the easement value was used in project justification.

Evaluation of the damage by sediment accumulation in the authorized Eufaula Reservoir was made by straight-line depreciation of the estimated construction cost, adjusted to long-term prices.

During field investigations, farmers were asked what changes had been made in the use of their flood plain land as a result of past flooding. They were asked what changes they would make in their use of the flood plain if flooding was reduced 50 percent. The indication from responses was that the changes in land use would be insignificant except in areas being damaged by sediment and scour. Therefore, land enhancement benefits are considered to be included in the benefits accruing as a result of sediment and scour reduction.

Recreation

Benefits from recreation were based on the value of a visitor day of use and the estimated number of days of use annually. Determination of the number of visitor days of annual use was based on secondary data, and surveys. The following factors were taken into consideration in determining the number of annual visitor days:

- a. The area available for use.
- b. Facilities available.
- c. The population and population trends within a 25-mile radius of the sites.

- d. Competitive recreational development in the 25-mile radius area.
- e. Policing and maintenance.
- f. Accessibility of site.
- g. Service facilities convenient to site.
- h. Proposed level of admission charges.
- i. Recreational capacity for sustained use.
- j. The opportunities for different types of recreation by seasons.

In estimating recreation benefits at multiple purpose site 15, a value of \$1.50 per visitor day was used. The average annual number of visitor days was estimated to be 23,200. The total average annual benefits of \$34,800 were discounted 5 percent to allow for a 4-year lag in benefit accrual.

Incidental recreational benefits were based on a value of \$0.50 per visitor day. These benefits were discounted 20 percent to allow for associated costs such as occasional clean-up, repair of fences and gates, liability insurance, etc. An additional discount of 16 percent was made also to make allowance for sediment pool depreciation and lag in maximum benefit accrual.

The consulting engineer for the Sparks municipal site No. 1 estimated that the alternative means of providing an equivalent water supply, pump station and water lines, would cost \$73,625. This cost was amortized in 100-years at 3 1/8 percent interest to arrive at an annual equivalent cost of \$2,412. The consulting engineer for Meeker Municipal site 15 estimated that the alternative means of providing an equivalent water supply, pump station and water supply lines would be \$422,278. This cost was amortized in 100 years at 3 1/8 percent interest to arrive at an annual equivalent cost of \$13,833. The annual costs were used as an estimate for the average annual municipal water supply benefits.

Redevelopment

The basis for determination of the amount of employment the installation of the structural measures will furnish unemployed and underemployed labor was based on data collected in interviews with contractors of similar projects by Service personnel. These data indicated that local labor costs in the project area approximate 14 percent of the construction cost. This percent of the value for structural measures in Lincoln County (\$2,683,610) was amortized in 100-years at 3 1/8 percent interest and converted to redevelopment benefit. Likewise the value of local labor employed in operation and maintenance over a 20-year period was converted to an average value for the project life and use as a redevelopment benefit.

Secondary Benefits

Secondary benefits, the net increase in the value of goods and services generated by the project, will be realized by workers, processors, and business establishments in the trade area. The evaluation of these benefits was limited to those which will occur locally as a result of project installation.

Local secondary benefits stemming from the project were estimated to equal 10 percent of the direct primary benefits accruing to structural measures, less 10 percent of reduced production values in project sites.

Costs

Installation costs were amortized over a 100-year period at 3 1/8 percent. Operation and maintenance costs were based on information from similar watersheds where the structures have been in operation for several years. The operation and maintenance were adjusted to long-term prices using the index projected by ARS in September 1957.

Methods and Procedures

Details of the procedures used in the investigation are described in the Economic Guide for Watershed Protection and Flood Prevention (Procedures for Use with the Historical Series Approach).



Figure 1A
TYPICAL CHANNEL CROSS SECTION

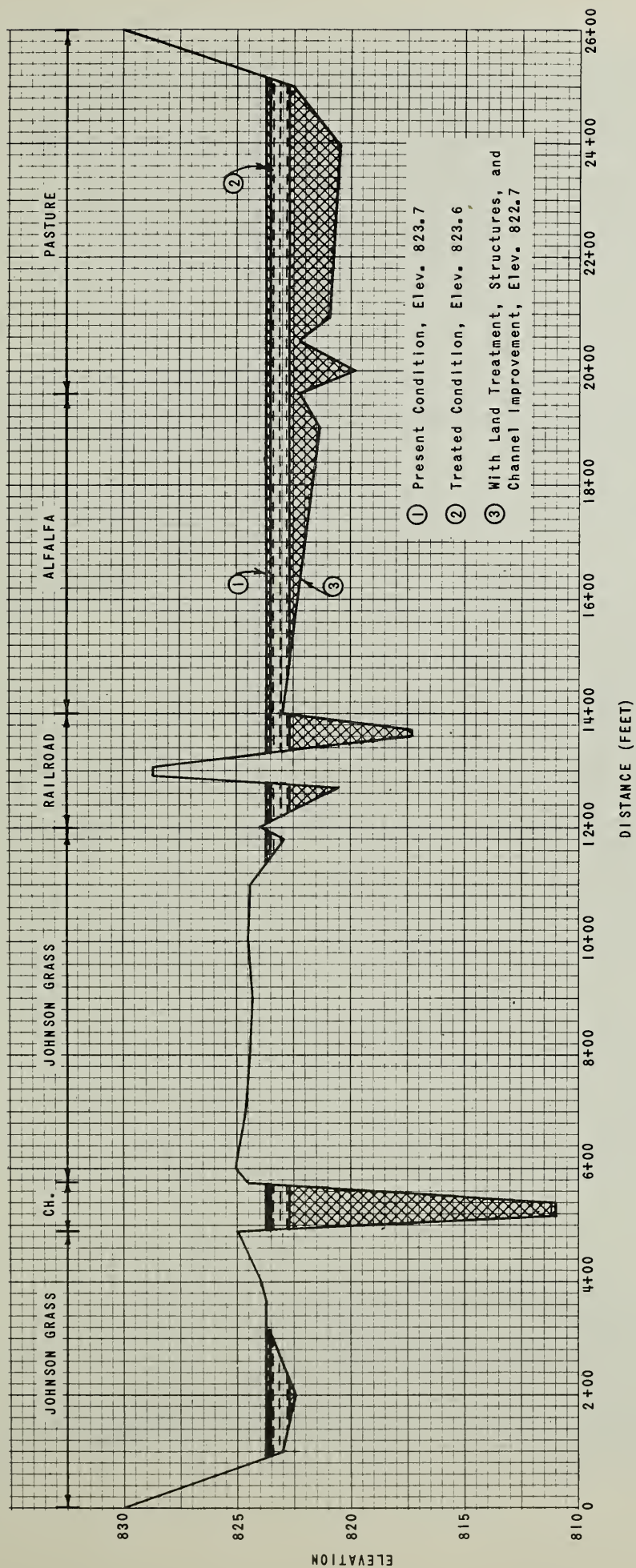


Figure 1
 DEGREE OF FLOOD REDUCTION
 QUAPAW CREEK WATERSHED
 Cross Section No. 8
 2.72" RAINFALL WITH .82" RUNOFF
 APPROXIMATELY 2 YEAR FREQUENCY

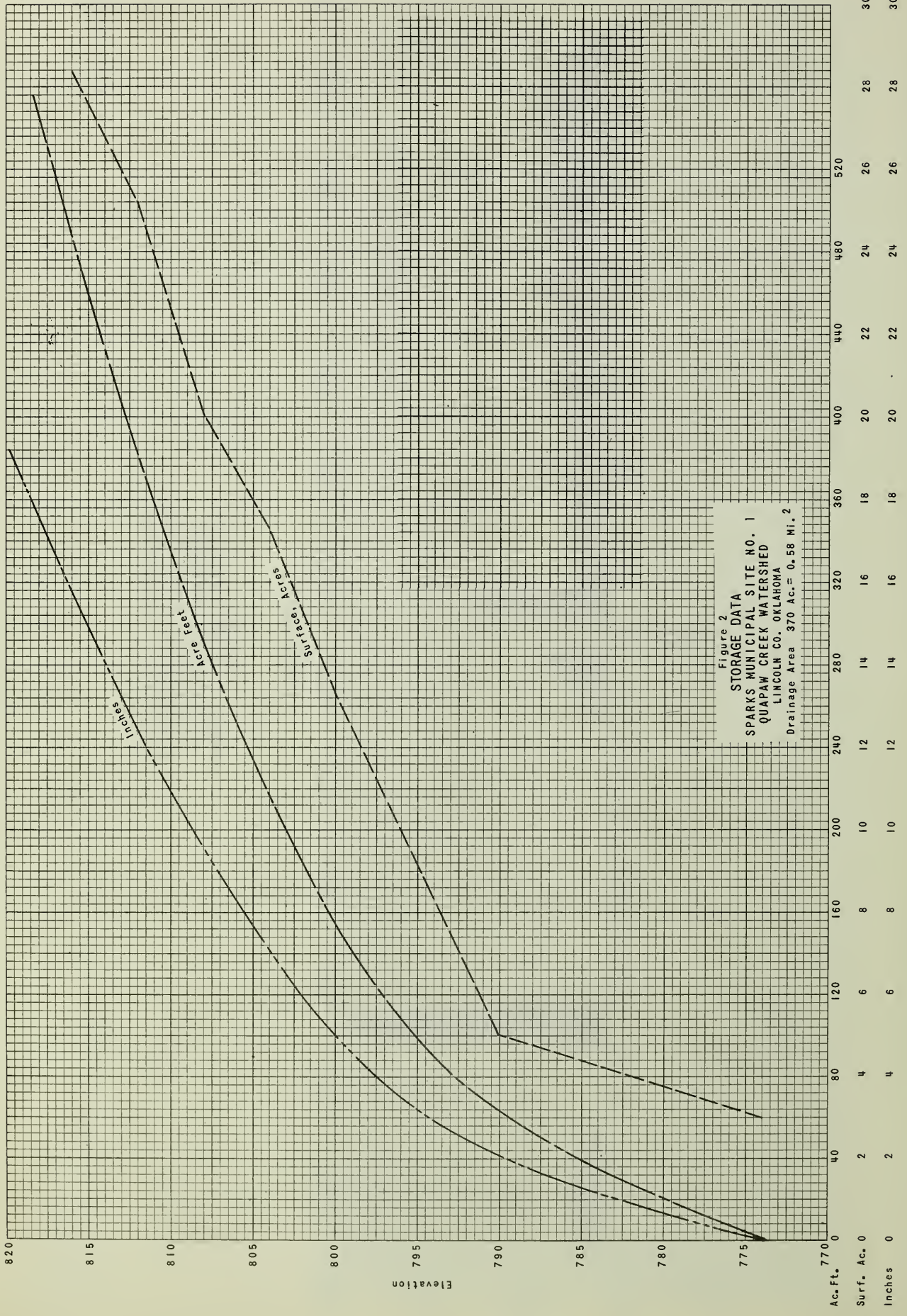
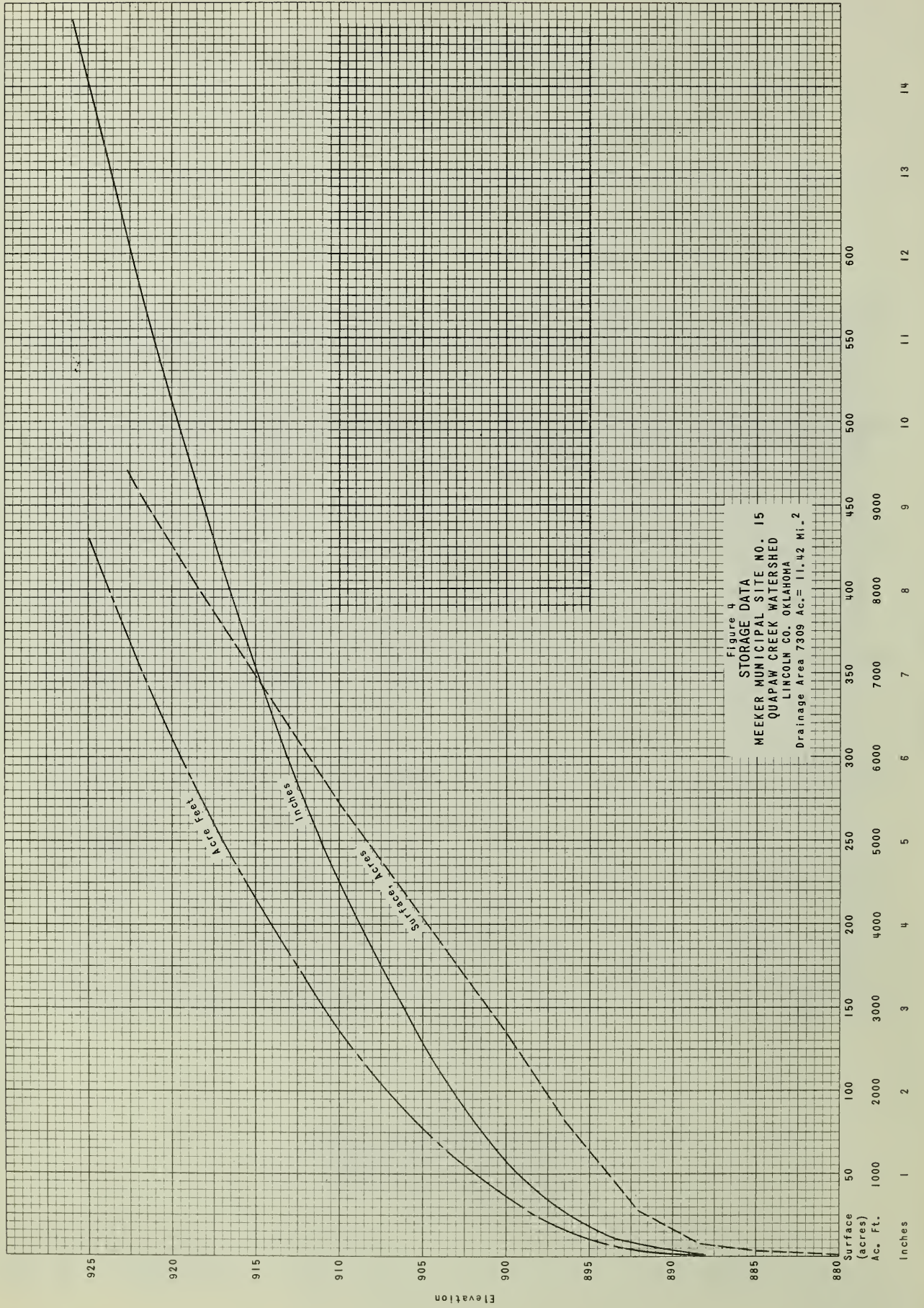




Figure 3
 RESERVOIR OPERATION STUDY
 Effect of Evaporation on Municipal Storage
 QUAPAW CREEK WATERSHED
 SITE No. 1



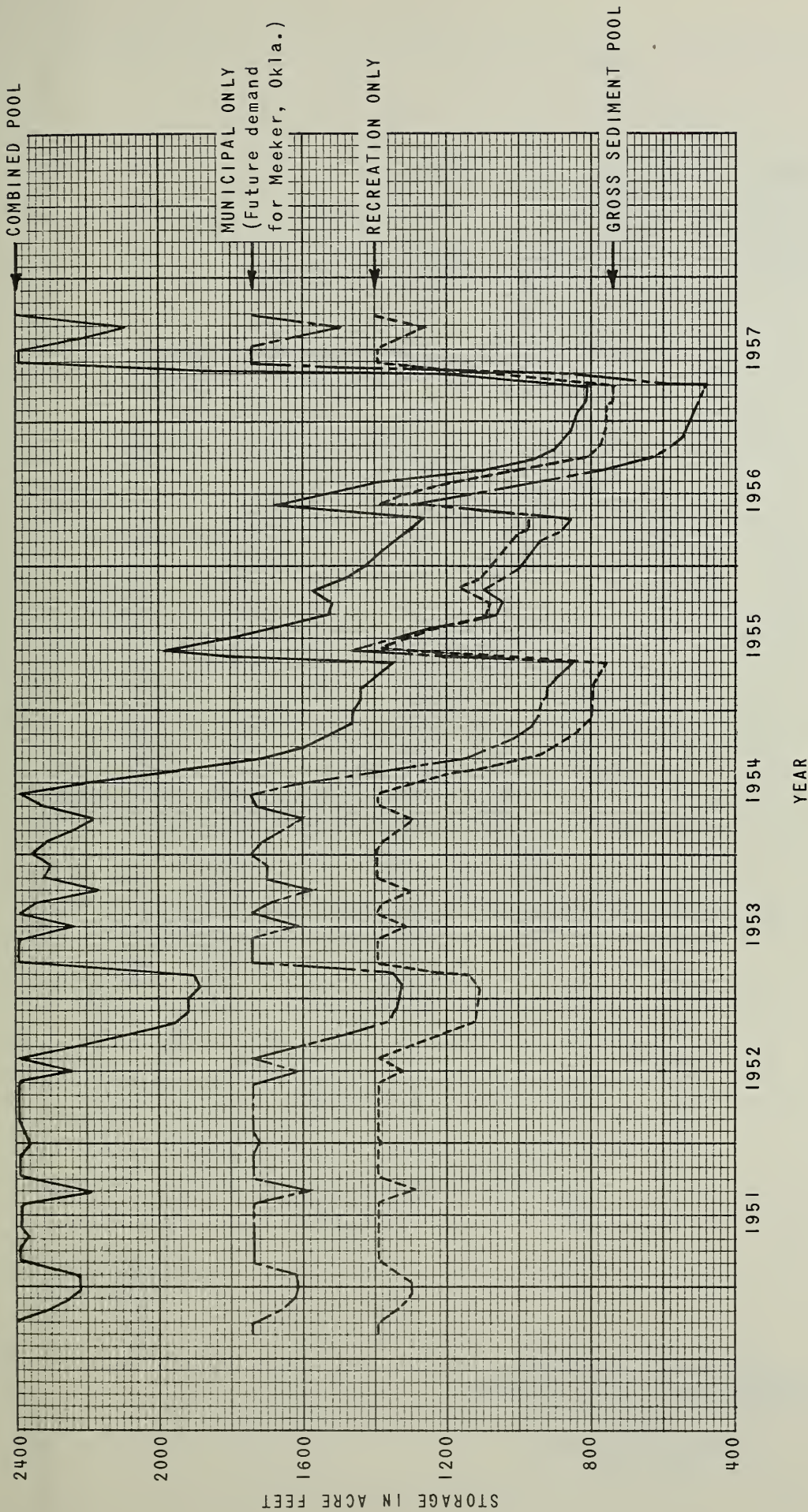


Figure 5
RESERVOIR OPERATION STUDY
 Effect of Evaporation on Municipal and Recreation Storage
 QUAPAW CREEK WATERSHED
 SITE No. 15

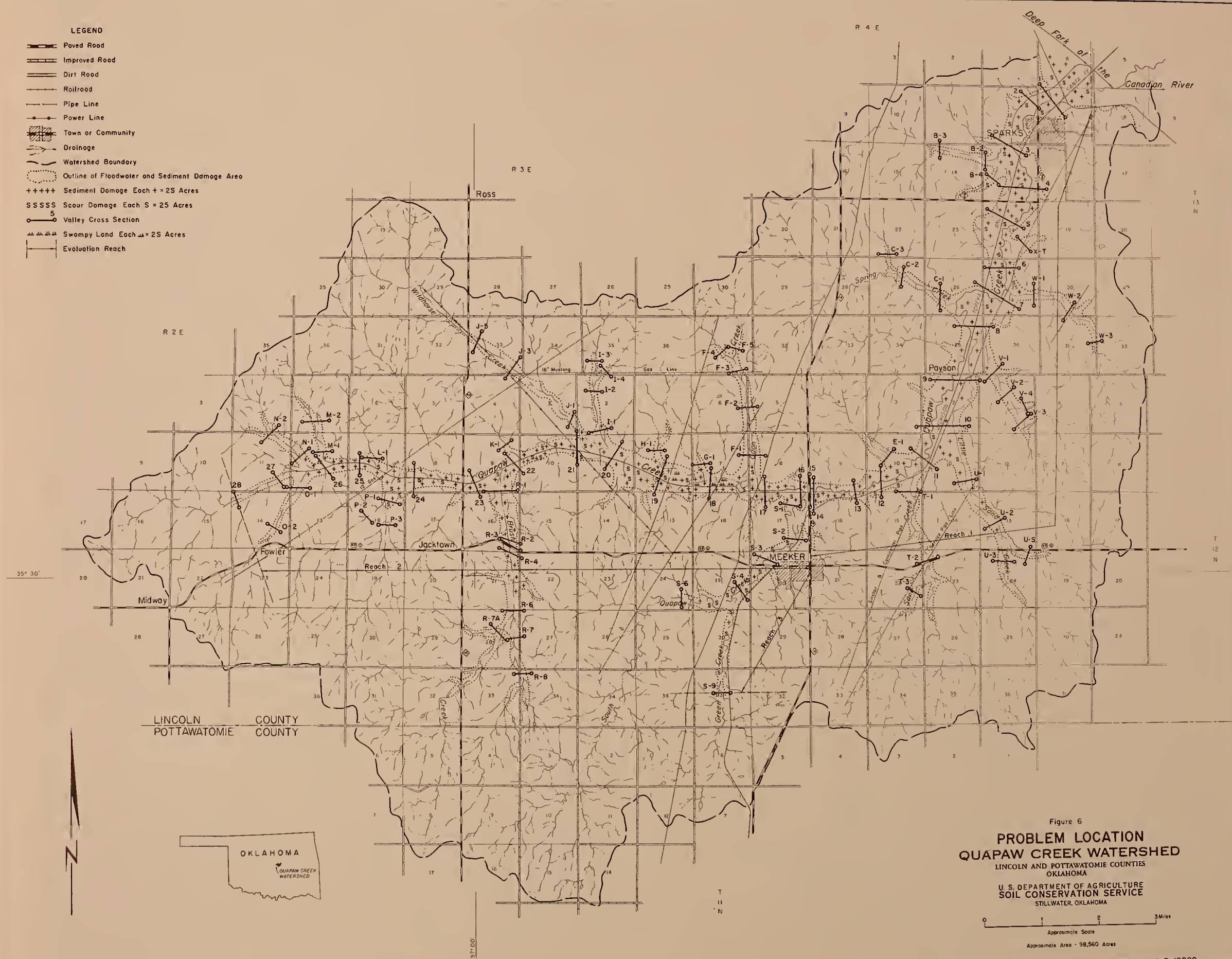
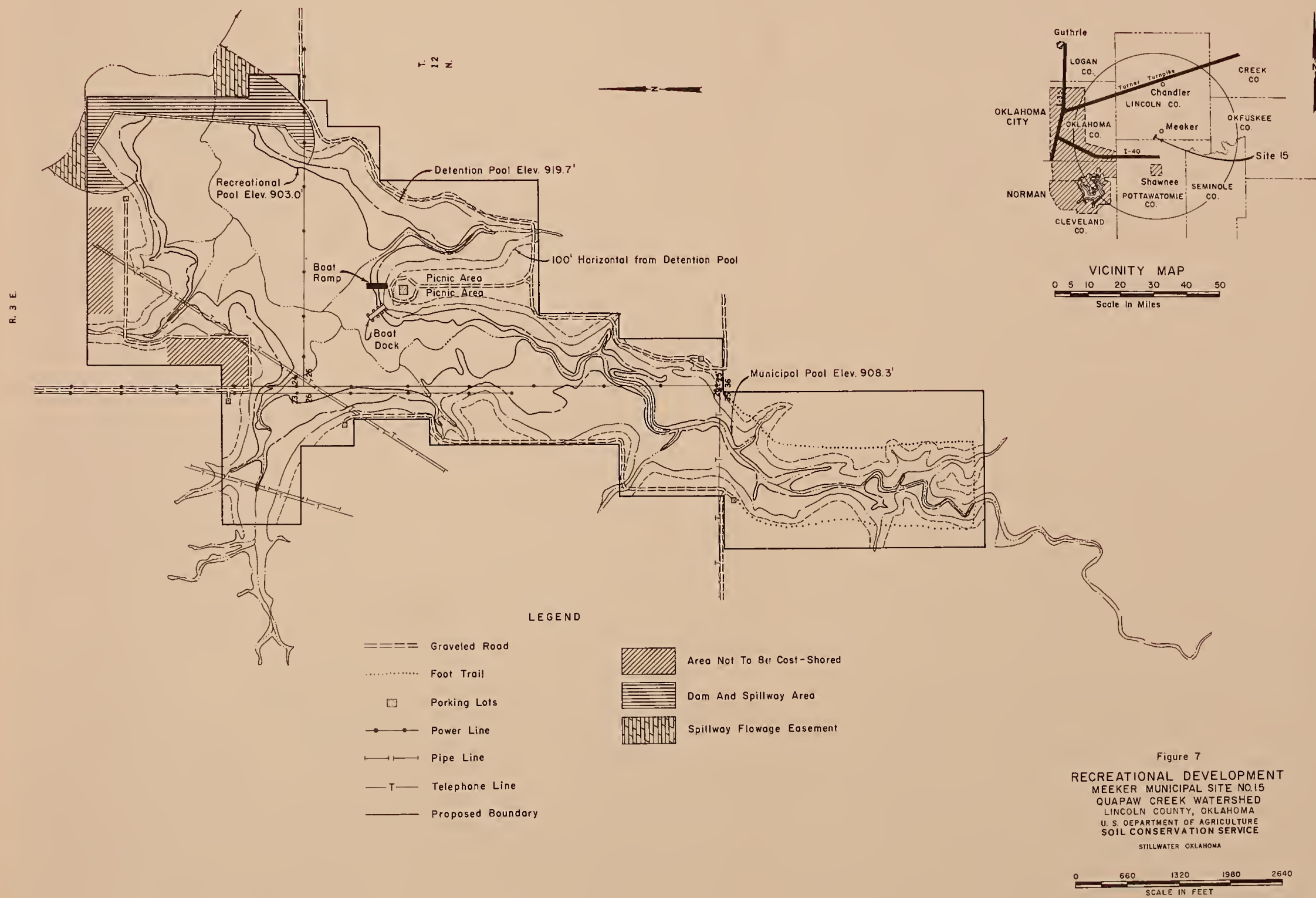


Figure 6
PROBLEM LOCATION
QUAPAW CREEK WATERSHED
 LINCOLN AND POTTAWATOMIE COUNTIES
 OKLAHOMA
 U. S. DEPARTMENT OF AGRICULTURE
 SOIL CONSERVATION SERVICE
 STILLWATER, OKLAHOMA

0 1 2 3 Miles
 Approximate Scale
 Approximate Area - 98,560 Acres

7-64 4-R-19228
 Rev. 7-64 4-R-12726



Revised 2-65

4-R-19,235

LEGEND

- Paved Road
- Improved Road
- Dirt Road
- Railroad
- Pipe Line
- Power Line
- Town or Community
- Drainage
- Watershed Boundary
- Floodwater Retarding Structure
- Multiple Purpose Structure
M B R-(Municipal & Recreation)
- Drainage Area Controlled by Structure
- Benefited Area
- Stream Channel Improvement
- Floodwater Diversion
- Site Number
- Dike
- Release Channel

SITE NUMBERS AND DRAINAGE AREAS

No.	Acres	No.	Acres	No.	Acres	No.	Acres
1	371	12	320	23	1722	34	576
2	723	13	858	24	576	35	614
3	2752	14	1618	25	1818	36	475
4	725	15	7309	26	2797	37	563
5	442	16	320	27	883	38	461
6	442	17	640	28	902	39	768
7	384	18	1421	29	531	40	851
8	1741	19	1626	30	1900	41	4345
9	467	20	1171	31	3110	42	467
10	1670	21	851	32	1690	43	1203
11	2547	22	717	33	576	44	467

R 3 E

R 4 E

R 2 E

LINCOLN COUNTY
POTTAWATOMIE COUNTY

OKLAHOMA

QUAPAW CREEK WATERSHED

Figure 8
PROJECT MAP
QUAPAW CREEK WATERSHED
LINCOLN AND POTTAWATOMIE COUNTIES
OKLAHOMA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
STILLWATER, OKLAHOMA

0 1 2 3 Miles

Approximate Scale
Approximate Area - 98,560 Acres

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SECTION OF A TYPICAL FLOODWATER RETARDING STRUCTURE

Plate 1



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